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JOINT HIGHWAY RESEARCH PROJECT

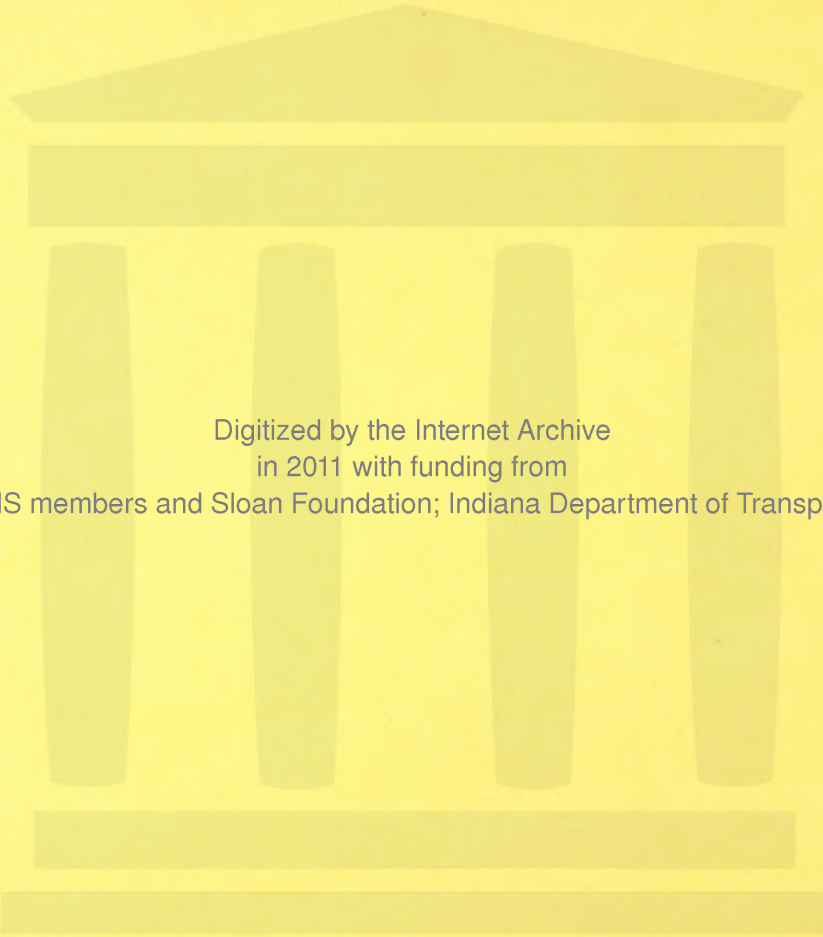
JHRP-76-16

FINLIN USER'S MANUAL

M. B. Roy



PURDUE UNIVERSITY
INDIANA STATE HIGHWAY COMMISSION



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User's Manual

FINLIN USER'S MANUAL

TO: J. F. McLaughlin, Director
Joint Highway Research Project

May 5, 1976

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

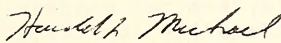
Project: C-36-62F

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The attached "FINLIN User's Manual" is provided for the computer program FINLIN developed in the HPR Part II Research Study "Performance of Pipe Culverts Buried in Soil". Its development and formulation is reported in the Interim Report "Predicting Performance of Pipe Culverts Buried in Soil", M. B. Roy, JHRP-76-15, May 1976.

This Report and its companion volume, JHRP-76-15, were presented to the JHRP Board at its meeting on May 5, 1976, and accepted as fulfillment of the objectives of Phase I of the Study. It is now forwarded for review, comment and similar acceptance by ISHC and FHWA.

Respectfully submitted,



Harold L. Michael
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16. Abstract This is a User's Manual for the Computer Program FINLIN (Finite element, Isoparametric, <u>Non-Linear</u> with <u>Interaction</u> and <u>No-tension</u>). It is a finite element computer program for analysis of flexible pipe culverts buried in soil. Details of mathematical formulations, developments of different element properties, and related information can be found in the Interim Report "Predicting Performance of Pipe Culverts Buried in Soil", M. B. Roy, JHRP-76-15, May 1976.			
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User's Manual
FINLIN USER'S MANUAL

by

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The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

This User's Manual is for the computer program for analysis of flexible pipe culverts buried in soils and reported in Interim Report "Predicting Performance of Pipe Culverts Buried in Soil", M. B. Roy, JHRP No. 15, May 1976.

Purdue University
West Lafayette, Indiana
May 5, 1976

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CHAPTER I. INTRODUCTION

FINLIN (Finite element, Isoparametric, Non-Linear with Interaction and No-tension) is a finite element computer program for analysis of flexible pipe culverts buried in soil. Curved bar segments have been used to simulate flexible pipes. A zero thickness special type of frictional element is used to simulate the occurrence of slip between pipe and soil. Isoparametric, linear-strain triangular elements are used to represent the soil. Non-linear, anisotropic, state of stress-dependent soil properties expressed in terms of octahedral stresses are used. Several option commands permit realistic analysis of a culvert problem in two dimensions. Incremental stages of construction, controlled slip between soil and pipe and no-tension analysis can be performed. The program has been written in FORTRAN IV source language using hard and soft wire facilities available in the CDC computer system. In this report, the procedure for preparation of input data for a problem will be discussed; a complete listing of the source program is included. Details of mathematical formulations, developments of different element properties, and related information can be found in the Interim Report - "Predicting Performance of Pipe Culverts Buried in Soil", by M. B. Roy, Purdue University, May, 1976, JHRP-76-15.

In any finite element analysis the first step is to bound the problem by a set of finite boundaries with appropriate boundary conditions. Then each region of different materials has to be distinguished. In the next step, each zone is subdivided into a number of characteristic finite elements maintaining continuity at the boundary between two elements. Then nodes and elements are numbered in sequence. Required material properties for every element need to be defined. In the case of nonlinear analysis, where material properties change depending upon the state of stress, parameters which govern the variation of properties need to be defined. Also, construction in layers, load application in increments, limited shear or slip in the pipe-soil inter-

action, and no-tension in soil must be accommodated.

Preparation of data for a real problem should take advantage of the fact that:

1. The boundaries need only define the areas of primary interest, and obvious features, like symmetry, should be recognized.
2. Smaller sized elements are needed in zones of maximum interest and/or high stress gradients; larger elements may be used elsewhere.
3. Each region is divided into an appropriate number and type of elements whose node points are numbered sequentially. The cost of a solution depends heavily on the numbering sequence of nodes even if the total number of nodes and elements remain the same. A useful general rule is to minimize the maximum difference between the highest and lowest node numbers in an element.

The next step is selection of the type of analysis, such as number of construction layers, number of increments of load in a given layer, interaction properties, no-tension in soil and other similar decisions. All information has to be digitized and checked for correctness.

CHAPTER II. COMPUTER PROGRAM

1. Types of Finite Elements

Several types of finite elements have been used in the program FINLIN. Description of each type follows.

Type I, Curved Bar Element

Segments of a ring have been used to represent flexible pipe, which has small thickness compared to the radius. Figure 1 shows a typical Type I element with two nodes, each node having three degrees of freedom - radial, tangential and rotational. The radius of the pipe, its stiffness EI (young's modulus times moment of inertia), and the nodal coordinates need to be defined. The position of the center of curvature is also necessary.

Type II, Interaction Element

This is a zero thickness, rectangular element with four nodes, each node having two degrees of freedom in the normal and tangential directions. Figure 2 shows a typical interaction element where the coordinates of nodes 1 and 4 (and 2 and 3) are initially the same. Coordinates of all four nodes, stiffness values in normal and tangential directions, E_n and E_s respectively, need to be defined. The program will modify the values of E_n and E_s according to the state of stress in these elements.

For both Type I and Type II elements, the program will perform the necessary coordinate transformation depending upon their position and orientation.

Type III, Isoparametric Triangular Element

This type of triangular element has three corner nodes and three intermediate (midpoint) nodes, each node having two degrees of freedom (Figure 3). The face 1-4-2 can be a

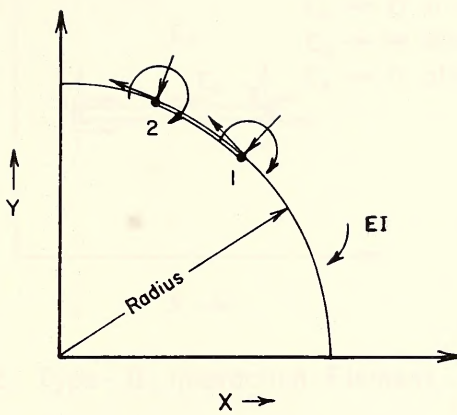


Figure 1. Type - I, Curved Bar Element

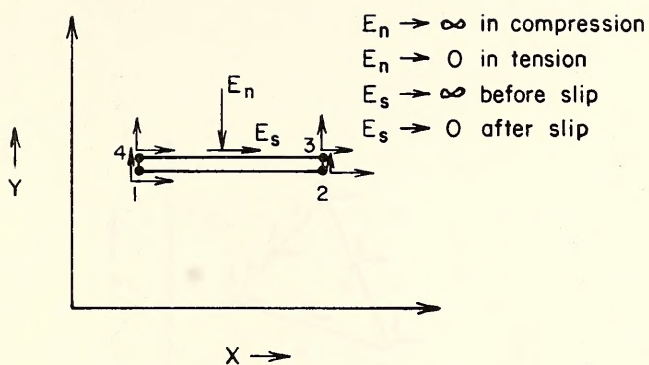


Figure 2. Type - II, Interaction Element

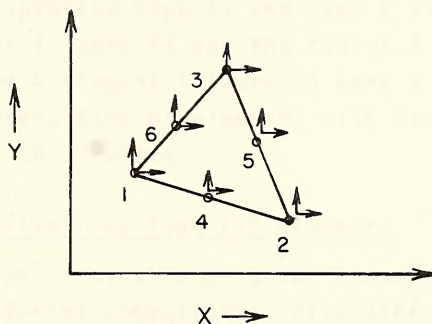


Figure 3. Type-III, Isoparametric Triangular Element

curved boundary. Nodes of the Type III element must be defined in the order shown in Figure 3. Coordinates of only corner nodes need to be defined. This element is used to simulate the soil medium and for thick pipes where rotation at pipe nodes are not significant. Required material properties for this type of element are modulus and poisson's ratio. Depending upon the nature of the material, linear or nonlinear properties can be used.

In case of analysis with no interaction element between pipe and soil, placing Type III element adjacent to Type I elements causes a difficulty in numerical procedure because nodes of 2 and 3 degrees of freedom lie at one point. To eliminate this problem Type IV and Type V elements are used. Type IV element (Figure 4) has the face 1-4-2 adjacent to the pipe. For Type V element (Figure 5) node 3 touches the pipe. Improper representation of elements will cause abnormal termination of the program.

Material Properties for Type III Elements

The program is capable of using linear, nonlinear and anisotropic material properties. Also different types of soils with distinct properties can be used. For linear materials only values of Young's modulus E and Poisson's ratio ν need to be defined. For anisotropic material, the ratio of moduli in vertical to horizontal direction has to be defined. For nonlinear properties, experimental data are directly used. It is to be noted that, in this program tangent modulus and tangent Poisson's ratio values are used for incremental analysis. Also octahedral normal and shear stresses have been used in the formulation. Nonlinear soil properties for any value of stress level and stress ratio are interpolated using cubic spline functions.

It is necessary to convert conventional test data (e.g. Figure 6) to a form which is acceptable to this program, as follows:

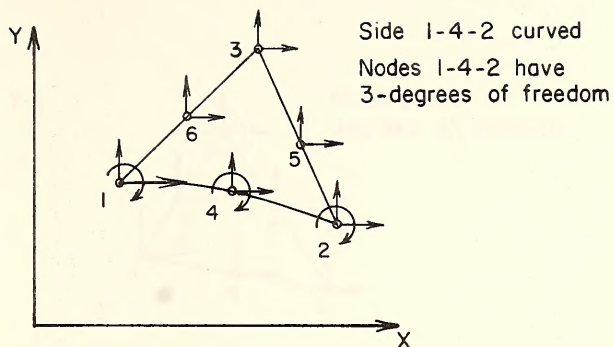


Figure 4. Type - IV, Triangular Element

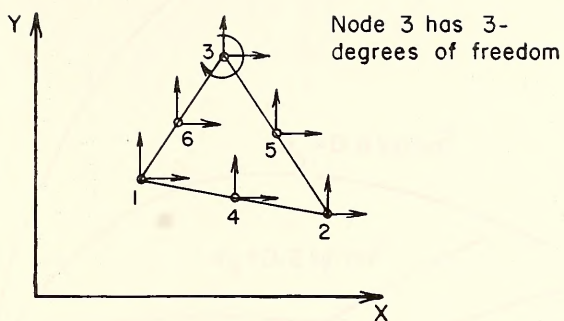


Figure 5. Type - V, Triangular Element

Figure 6. Plane Strain Test on Loose Monterey
No. 0 Sand (after Lee, 1972)

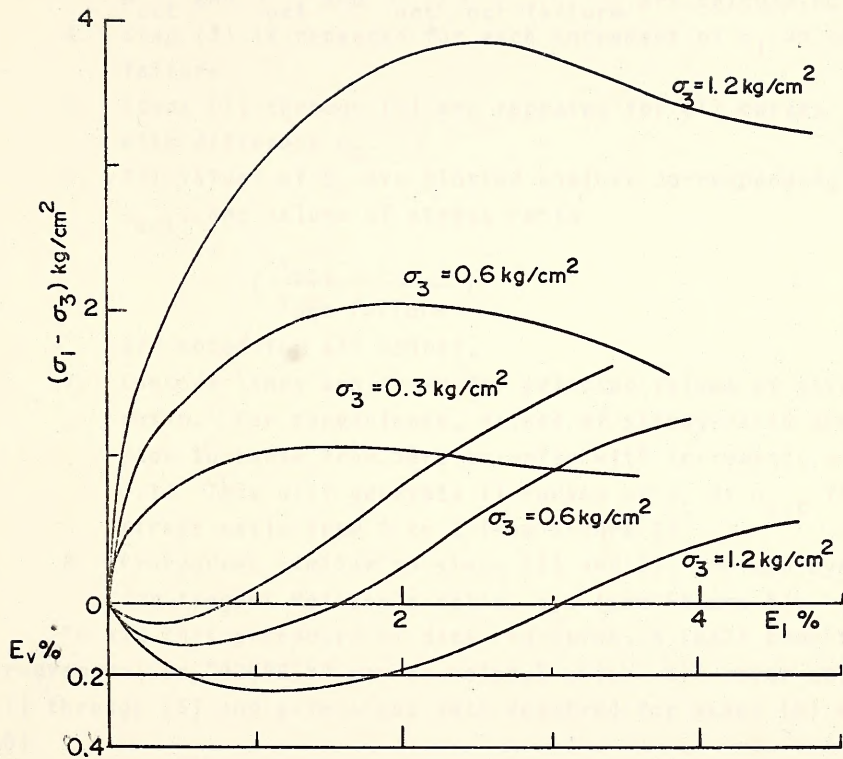


Figure 6, Plane Strain Test on Loose Monterey
No. 0 Sand (after Lade, 1972)

1. Select successive values of $(\sigma_1 - \sigma_3)$, ϵ_v and ϵ_1 from the test data, at a given σ_3 starting from zero.
2. Cubic splines are fitted to the data.
3. Small increments of ϵ_1 are chosen, and values of σ_2 , E_t and ν_t are computed from the generalized Hooke's Law. With σ_1 , σ_2 , and σ_3 known, values of σ_{oct} and τ_{oct} and $\tau_{oct}/\tau_{oct \text{ failure}}$ are calculated.
4. Step (3) is repeated for each increment of ϵ_1 up to failure.
5. Steps (1) through (4) are repeated for all curves with different σ_3 .
6. All values of E_t are plotted against corresponding σ_{oct} , and values of stress ratio

$$\left(\frac{\tau_{oct}}{\tau_{oct \text{ failure}}} \right)$$

are noted for all points.

7. Contour lines are drawn for selected values of stress ratio. For convenience, values of stress-ratio are made to range from zero to unity with increments of 0.1. This will generate 11 curves of E_t vs σ_{oct} for stress ratio from 0 to 1 (see Figure 7).
8. Procedures similar to steps (6) and (7) are employed for tangent Poisson's ratio, ν_t , (see Figure 8).

To aid this procedure of data reduction, a small computer program called "PROPRTY" can be helpful which will cover steps (1) through (5) and prints out data required for steps (6) and (8).

Description of the Computer Program

The program FINLIN has been divided into several primary sections which are called OVERLAYS. Each OVERLAY performs specific computations and stores the results for future use. Figure 9 shows the principal organization of the program and several OVERLAYS. Each OVERLAY consists of one main program

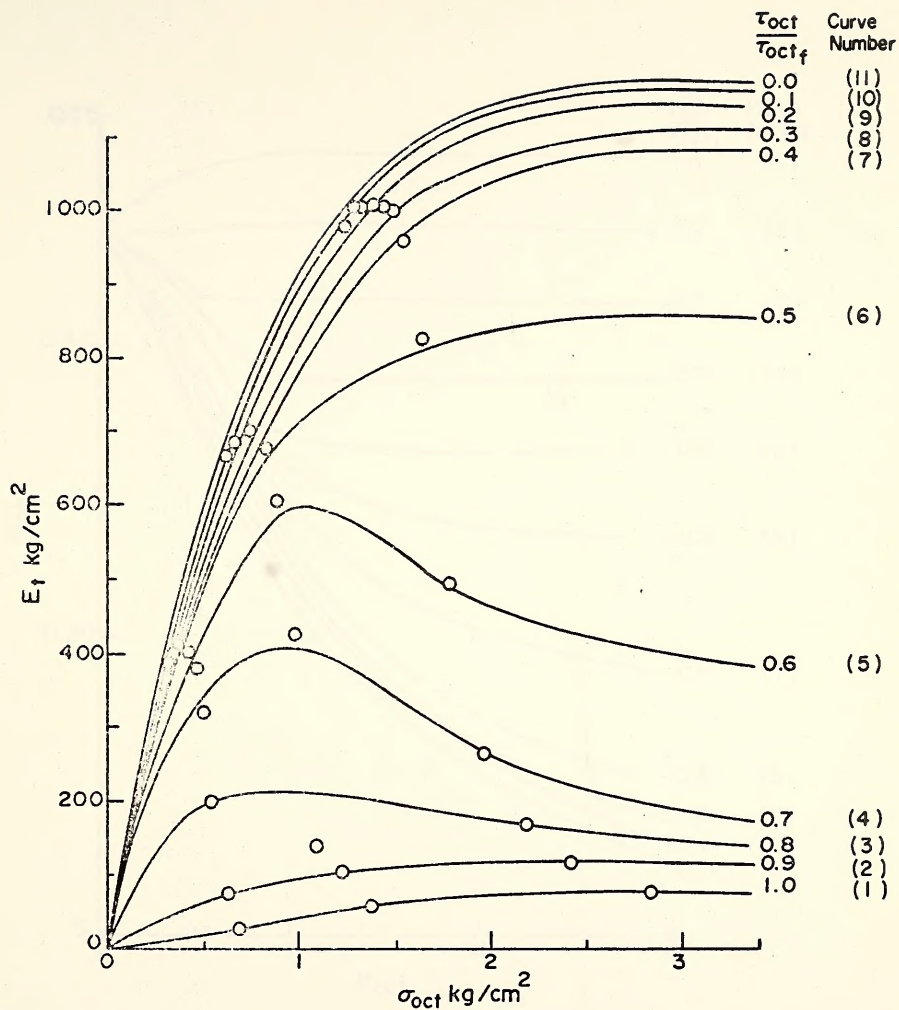


Figure 7 , Tangent Modulus vs. Octahedral Normal Stress and Failure Ratio for Loose Sand.

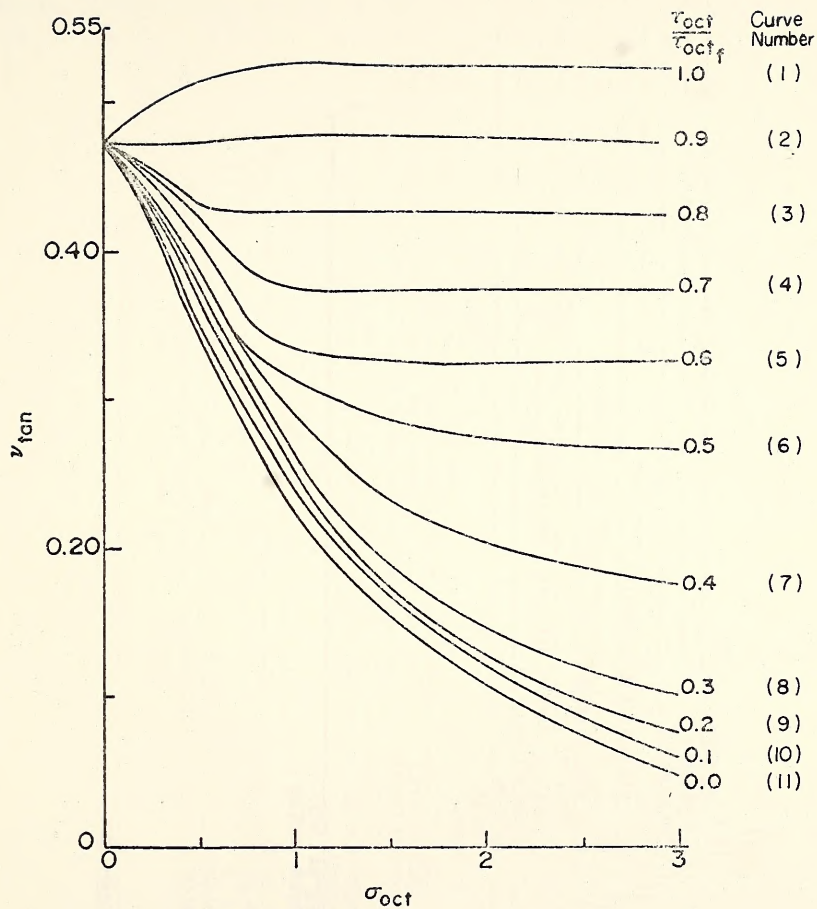


Figure 8 , Tangent Poisson's Ratio vs. Octahedral Normal Stress and Failure Ratio for Loose Sand.

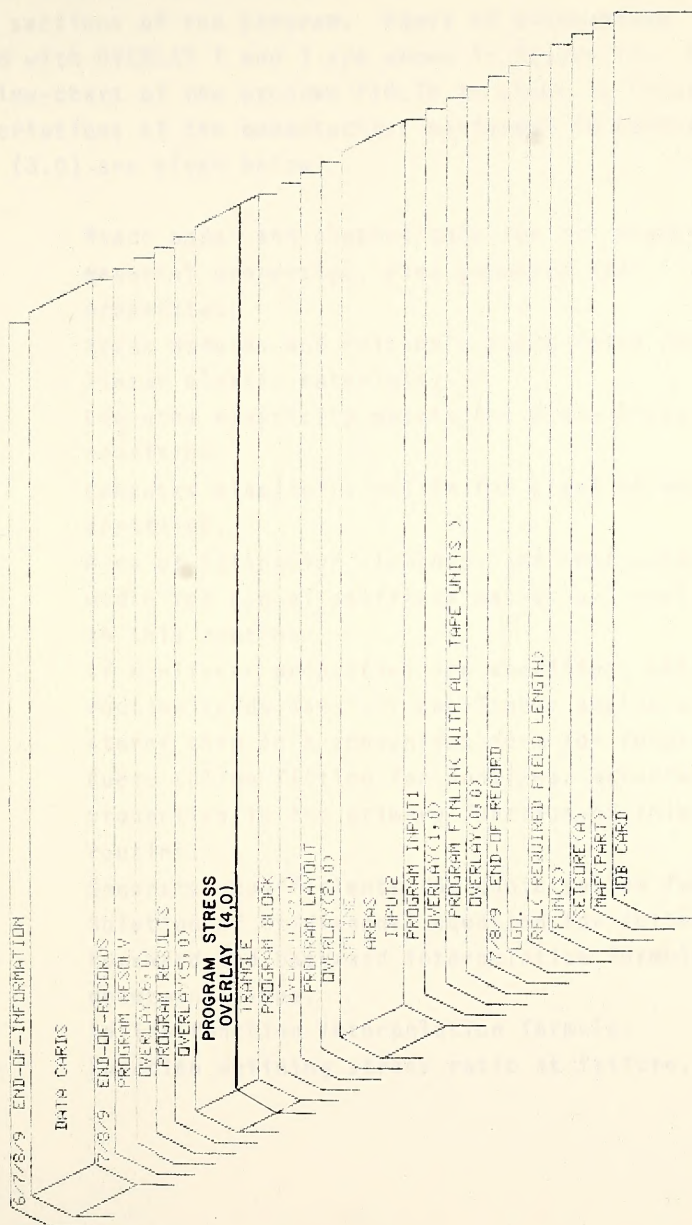


Fig. 9 ARRANGEMENT OF ROUTINES IN "FINLIN"

and several subroutines. OVERLAY 1 and 3 are the two most important sections of the program. Names of subroutines associated with OVERLAY 1 and 3 are shown in Figure 10. A general flow-chart of the program FINLIN is shown in Figure 11. Brief descriptions of the computations performed in OVERLAY (1.0) and (3.0) are given below.

INPUT1 -	Reads nodal and element data for all elements, material properties, pipe geometry and properties.
INPUT2 -	Reads modulus and Poisson's ratio value for linear elastic materials.
PLSTRS -	Computes elasticity matrix for plane stress condition.
PARAMTR -	Computes elasticity matrix for plane strain condition.
AREAS -	Area of triangular elements, and semi-band width for global stiffness matrix are evaluated in this routine.
SPLINE -	If nonlinear properties are specified, this routine reads data for non-linear analysis and stores them in a convenient form for future use.
SPLFIT -	Cubic spline fitting for nonlinear material properties is the primary function of this routine.
COFRIT -	Generates coefficients for cubic spline function.
TRIDGNL -	Solution of tridiagonal equation for spline fit.
FD and BD -	Foreward and backward interpolation formulae to determine slope.
ORDINET -	Spline-function interpolation formula.
FAILURE -	Function defining stress ratio at failure.

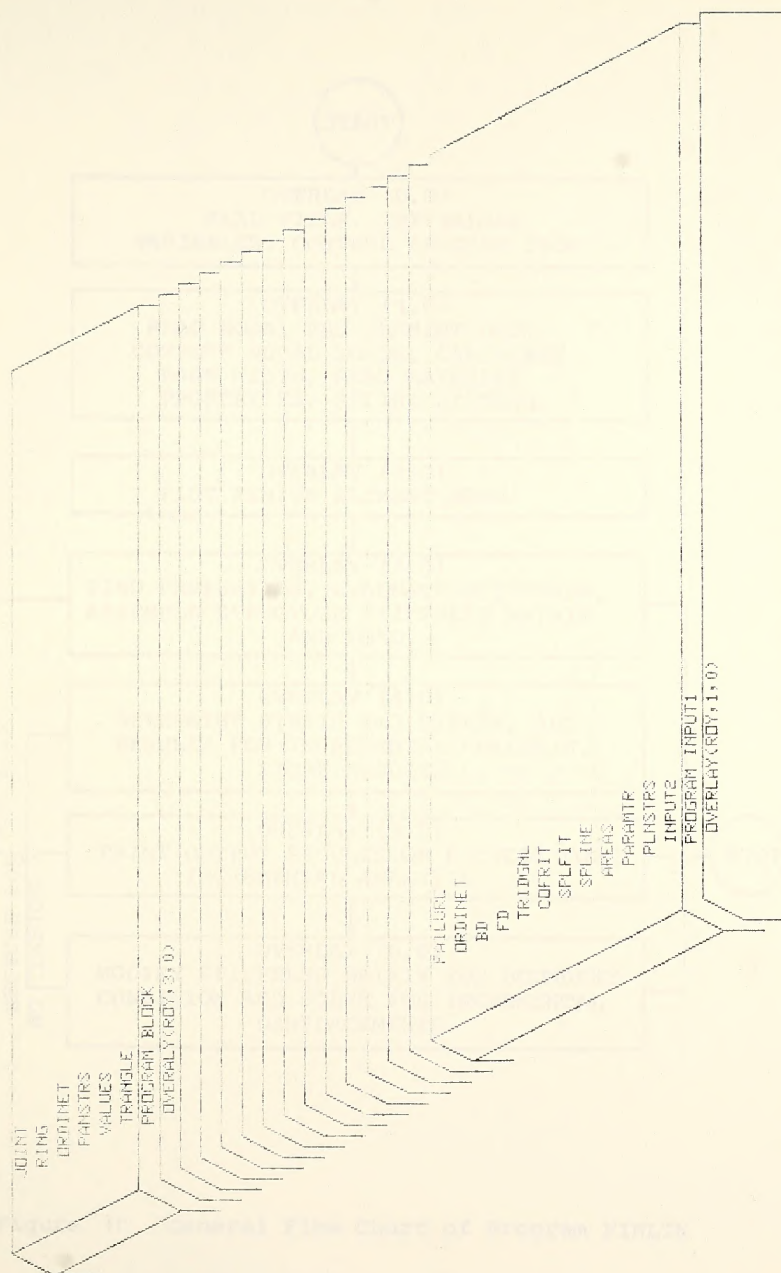


Fig. 10 SUBROUTINES IN OVERLAY (1.0) AND (3.0)

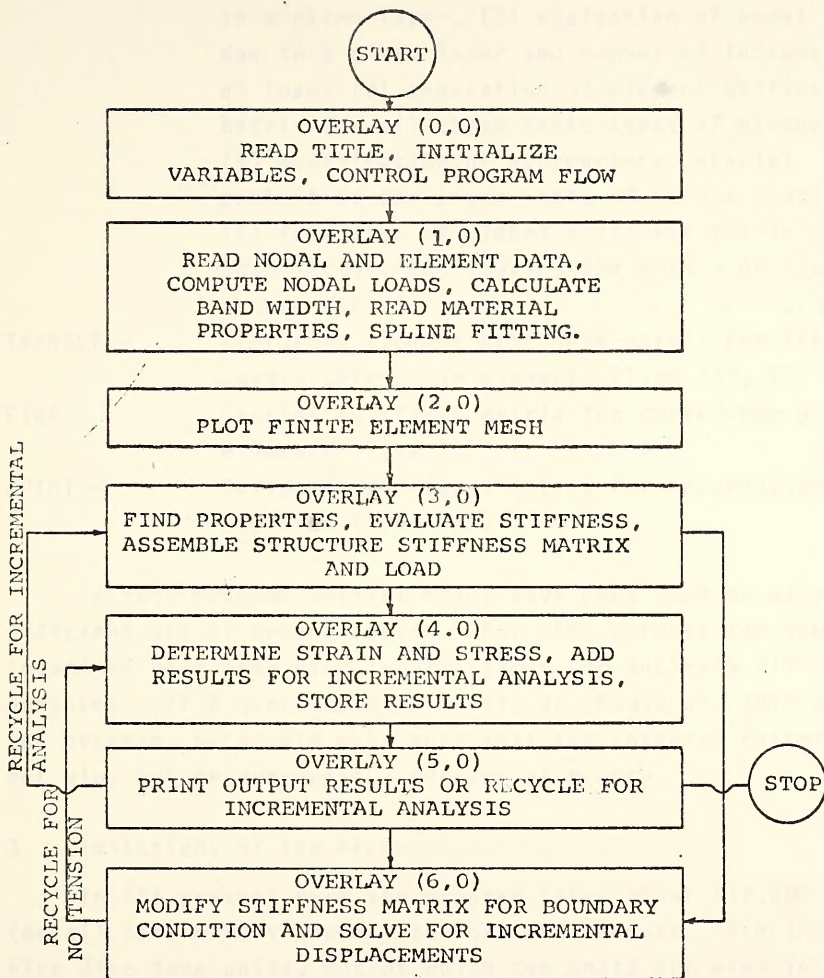


Figure 11 General Flow Chart of Program FINLIN

- BLOCK - This is the most important routine in FINLIN. Primary functions are (1) selection of elements in a given layer, (2) evaluation of nodal loads due to a given layer and number of increments of load, (3) generation of element stiffness matrix for all three basic types of elements, (4) modification of appropriate material properties for given state of stress condition, (5) formation of global stiffness matrix and load vector, (6) storing the matrix on tape for future use.
- TRANGLE - Evaluates element stiffness matrix for linear-strain-triangular elements (Type III, IV, V).
- RING - Creates stiffness matrix for curved-bar or ring elements (Type I).
- JOINT - Evaluates stiffness matrix for interaction elements (Type II).

In this program several means have been used to make efficient use of memory spaces. For this purpose the same locations have been used several times for entirely different purposes. If a user wants to modify or change any portion of the program, he should make sure that the intended changes do not wipe out or overwrite a portion of memory.

3. Limitations of the Program

In its present form the program takes about 112,000 (octal) core memory spaces to load and execute. FINLIN uses nine disc tape units, out of which two units are used for INPUT, OUTPUT, five for random access mass storage and two for intermediate storage purposes. Limitations of the program are listed below (they can be modified easily by changing a few cards):

- (1) Total number of nodes: (NNODES) = 550
- (2) Total number of elements: (NELEMNT) = 250
- (3) Different types of materials: (MATRIAL) = 25
- (4) Increments of stress ratio in Figure 7 and 8 = 0.1
- (5) Maximum number of points for nonlinear material properties = 7
- (6) Maximum semi-bandwidth for global stiffness matrix (including diagonal) = 103

However, semi-bandwidth capacity can be modified easily by making changes as follows:

- (a) Estimate the maximum semi-bandwidth (including the diagonal term). If it is even, add one and make it odd numbered, which is the final semi-bandwidth (N) of the system. Numerals in the indicated places should at least be N.
- (b) OVERLAY (0.0), Line: FLN-36, NSIZE = N
- (c) OVERLAY (3.0), Line: BLK-15
DIMENSION A(N,N), ARRAY (N)
- (d) OVERLAY (6.0), Line: SOL-10
DIMENSION A(N,2N), B(2N), ARRAY(N)
- (e) SUBROUTINE MODIFY, Line: 3
DIMENSION A(N,2N), B(2N).

CHAPTER III. INPUT DATA CARDS FOR PROGRAM "FINLIN"

1st Card Type: TITLE, MESH

FORMAT (13A 6, 12)

One card identifying the problem.

Col. 2-78: alphanumeric description of the problem to be printed in the output.

Co. 79-80: if greater than 0, a plot of finite element mesh is generated by CALCOMP plotter. If zero or blank, no plot is generated.

2nd Card Type: NNODES, NELEMNT, MATERIAL, NPRSR, LAYERS, ISTOP

FORMAT (2I5, 2I3, 2X, I2, 2X, I2)

One card defining problem.

Col. 1-5: NNODES - Total number of node points.

Col. 6-10: NELEMNT - Total number of elements (all types included).

Col. 11-13: MATERIAL - Total number of different soil types.

Col. 14-16: NPRSR - 0

Col. 19-20: LAYERS - Number of construction layers.

Col. 23-24: ISTOP - If zero, linear elastic soil properties, if greater than zero, nonlinear soil properties.

3rd Card Type: NTYPE, GAMA, TYPE

FORMAT (I5, F10.0, 10A6)

Soil type cards, one card for each soil type, total number = MATERIAL

Col. 1-5: NTYPE - Soil-type identification number.

Col. 6-15: GAMA - Unit weight of soil.

Col. 16-75: TYPE - Alphanumeric description of this soil type.

4th Card Type: ANLSIS, DELTA

FORMAT (A6, F5.0)

One card specifying type of analysis and angle of friction between soil and pipe.

Col. 1-6: PLSTRS - For plane-stress analysis.

PLSTRN - For plane-strain analysis.

Col. 7-11: DELTA - Angle of friction between pipe material and soil adjacent to pipe, in degrees.

5th Card Type: Two cards per soil material type, total number = 2X MATERIAL, specifying initial modulus and Poisson's ratio for each soil type.

(a) 1st Card - E

FORMAT (E10.0)

Col. 1-8: E - Initial modulus.

(b) 2nd Card - NUE

FORMAT (F5.0)

Col. 1-5: NUE - Initial Poisson's ratio.

6th Card Type: These cards are required only for nonlinear materials i.e. if ISTOP is greater than zero (in 2nd Card Type). This set of cards is repeated for each nonlinear soil type. If ISTOP = 0 or blank, these cards are not required.

(a) NP, PSI, PHI, ANISO, DELTA, FACTOR

FORMAT (I5, 5F10.0)

One card identifying soil properties.

Col. 1-5: NP - Number of points on each tangent modulus and tangent Poisson's ratio vs. σ_{oct} curve.

Col. 6-15: PSI - Factor defined as

$$\Psi = \frac{\sigma_2}{(\sigma_1 + \sigma_3)}$$

Col. 16-25: PHI - Friction angle for soil, in degrees.

Col. 26-35: ANISO - Anisotropy ratio,

$$\frac{E_x}{E_y}$$

If isotropic, ANISO = 1.0

- Col. 36-45: DELTA - Angle of friction, in degrees between pipe and soil.
- Col. 46-55: FACTOR - Conversion factor for σ_{oct} and tangent modulus, e.g. $\sigma_{oct} = \text{FACTOR} * \sigma_{oct}$ and $E_t = \text{FACTOR} * E_t$.
If no conversion is required, FACTOR = 1.0

(b) XP(I)

FORMAT (8F10.0)

σ_{oct} values of nonlinear property cards, total number values = NP, up to 8 values per card.

Col. 1-10: NP(1) - 1st value of σ_{oct} .

Col. 11-20: NP(2) - 2nd value of σ_{oct} .
and so on.

(c) EP, PSNR

FORMAT (2F10.0)

These set of cards define the nonlinear material properties. Two sets of curves are required

(1) for tangent modulus, E_t vs σ_{oct} for stress-ratio ranging from 0.0 to 1.0 and (2) same type of curves for tangent Poisson's ratio ν_t , each curve of E_t and ν_t is defined by NP number of points, so total number of cards = NP x 11.

Col. 1-10: EP - Tangent modulus value.

Col. 11-20: PSNR - Tangent Poisson's ratio value

Note: (1) First NP cards should read the values of E_t and ν_t for increasing values of σ_{oct} starting from $\sigma_{oct} = 0$.

(2) The first set of NP cards are for curve of stress ratio = 1. The second set of NP cards will stand for stress ratio = 0.9 and so on. The last set of NP cards will read values of E_t and ν_t for stress-ratio = 0.0.

(3) A set of cards which includes cards from (a) to (c), define a complete set of Type 6 cards. As no material number has been attached to it, the sequence in which the set of cards are placed, will define the soil type. For example, the first complete set of type 6 cards (which includes (a), (b) and (c) type cards) will automatically be defined for Type 1 (NTYPE in 3rd Card Type) soil and the second set of type 2 and so on.

7th Card Type: NREAD, FACTOR
FORMAT (I5, F10.0)

Col. 1-5: NREAD - Total number of node point data cards. The triangular finite elements have six nodes i.e. three corner nodes and three mid-side nodes. Co-ordinates of mid-side nodes are calculated by the program. Except for defining boundary conditions, these nodes need not be defined.

Col. 6-15: FACTOR - Conversion factor for node point coordinates such as Ft. to Meter. If no conversion is required, FACTOR = 1.0.

8th Card Type: NN, NCODE, X, Y
FORMAT (I5, 5X, I2, F10.0, 20X, F10.0)
Nodal cards, one card per nodal point, total number = NREAD.

Col. 1-5: NN - Node point number.

Col. 11-12: NCODE - Node point boundary condition. The following table describes values of NCODE to represent desired boundary condition.

NCODE	Node Type	Boundary Condition
0	2 degrees of freedom in X and Y directions	Free X and Y directions.
1		Fixed in X and free in Y directions.
2		Free in X and fixed in Y directions.
3		Fixed in both X and Y directions.
4	3 degrees of freedom in X, Y direction and in rotation (θ)	Free in X, Y and θ directions.
5		Fixed in X, free in Y and θ directions.
6		Fixed in Y, free in X and θ directions.
7		Fixed in θ , free in X and Y directions.
8		Fixed in X and θ , free in Y directions.
9		Fixed in Y and θ , free in X directions.

Col. 13-22: X - X co-ordinate of node point.

Y - Y co-ordinate of node point.

Nodal data cards may be placed in any order.

9th Card Type: IEL, IX

FORMAT (I3, 2X, 2(3I5, 5X), 4X, I1, 3X, I2)

Element cards, one card per element total
number = NELEMNT Cards.

Col. 1-3: IEL - Element number.

Col. 6-10: IX(1) - Node number 1 of element no. IEL.

Col. 11-15: IX(2) - Node number 2 of element no. IEL.

Col. 16-20: IX(3) - Node number 3 of element no. IEL.

Col. 26-30: IX(4) - Node number 4 of element no. IEL.

Col. 31-35: IX(5) - Node number 5 of element no. IEL.

Col. 36-40: IX(6) - Node number 6 of element no. IEL.

Col. 50: IX(7) - Element type identification number.

Col. 54-55: IX(8) - Material type identification number.

Element types 1, 2, 3 and corresponding node numbers are shown in Figure 1 to Figure 3.

This numbering scheme has been used in the program. For type 4 and type 5 elements see Figures 4 and 5.

The element data cards can be placed in any order.

10th Card Type: ZAI(1), ZAI(2), ZAI(3)

FORMAT (3F10.0)

One card defining the point where stress of triangular element is required. (See Figure 12 for definition of ZAI).

Col. 1-10: ZAI(1) -

Col. 11-20: ZAI(2) - Area coordinates.

Col. 21-30: ZAI(3) -

11th Card Type: XCEN, YCEN, RADIUS, EI

FORMAT (3F10.0, E10.0)

One card defines center of circular pipe, radius and stiffness.

Col. 1-10: XCEN - X-coordinate of center of pipe.

YCEN - Y-coordinate of center of pipe.

RADIUS - Radius of pipe.

EI - Stiffness of pipe, Young's modulus times moment of inertia of pipe cross section per unit length.

12th Card Type: This card is required only when a plot of finite element mesh of the problem is required, which is specified in 1st Card Type. If Col. 79-80 is zero or blank no plot is generated. If any number is punched in Col. 79-80, a plot will be generated and in that case only this card is required.

XMAX, YMAX, YCEN

FORMAT (3F10.0)

Col. 1-10: XMAX - Maximum size of mesh in X-direction.

YMAX - Maximum size of mesh in Y-direction.

YCEN - Y-coordinate of center of pipe.

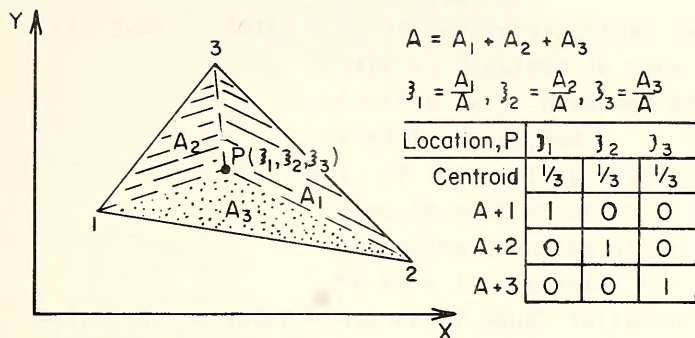


Figure 12. Definition of Area Co-ordinates

13th Card Type: NOTENSN, INTER, NSTEP, H1, H2, KN, KS, NITER
 FORMAT (3I2, 4X, 2F10.0, 2E10.0, I5)

This card contains very important information regarding type of analysis required. Total number of cards = LAYERS (as specified in Col. 19-20 of 2nd Card Type).

Col. 1-2: NOTENSN = 0, if soil is allowed to take tension.
 = 1, if 'no-tension' in soil analysis is required.

Col. 3-4: INTER = 0, if 'no-interaction' between soil and pipe is required in type II elements.
 In this case, pipe and soil are rigidly connected.
 = 1, if interaction between soil and pipe is desired which will permit slip depending upon the state of stresses in type II elements.

Col. 5-6: NSTEP - Number of equal increments of application of gravity load in a particular layer.

Col. 11-20: H1 - Starting height of a construction layer being analyzed.

Col. 21-30: H2 - Finish height of a construction layer being analyzed.

Col. 31-40: KN - Normal stiffness of pipe-soil interaction element (type II) before failure in tension.
 In case tension develop in an interaction element, the program will modify value of this stiffness.

Col. 41-50: KS - Shear-stiffness of pipe-soil interaction element (type II) before failure. If INTER = 0, value of KN and KS are kept unchanged in all interaction elements throughout the analysis, which simulates rigid connection if values of KN and KS are considerably high. If INTER > 0 values of KN and KS are modified based on failure conditions specified for an interaction element.

Col. 51-55: NITER - Maximum number of iterations specified for 'no-tension' analysis. If the solution does not converge after specified number (= NITER) of iterations, farther execution will be stopped and a message will be printed.

Input Data Cards for Program 'PROPRTY'

In program FINLIN, an octahedral stress-strain system and tangent modulus and tangent Poisson's ratio values have been used for representing nonlinear soil properties. Required data for nonlinear properties in FINLIN (data card type 6), is difficult to get from conventional triaxial or plane strain tests.

In program FINLIN, some routine calculations and interpolations have to be performed to prepare data for card type 6. The program PROPRTY has been written to aid in generation of the data required for interpolation. This program accepts actual test data and interpolates using spline function, prints values of octahedral stress, strain, stress-ratio, tangent modulus, tangent Poisson's ratio and similar informations.

1st Card Type: TITL

FORMAT (10A8)

Col. 2-80: TITL - Alphanumeric identification of soil and test; one card.

2nd Card Type: TEST, NOCURVS, RF

FORMAT (A6, I3, F10.0)

One card defines type of test performed and other information.

Col. 1-6: TEST = PLSTRS for plane-stress test and
= PLSTRN for plane-strain test performed
on the sample.

Col. 7-9: NOCURVS - Number of confining pressures used in the test; should at least be three.

Col. 10-19: RF - Ratio of τ_{oct}/σ_{oct} at failure.

3rd Card Type: SIGMA3, NP

FORMAT (5X, F10.0, I5)

One card specifies value of confining pressure and number of points for this test with given confining pressure.

Col. 6-15: SIGMA3 - Confining pressure.

Col. 16-20: NP - Number of points on a curve of given σ_3 .

4th Card Type: XP, YP, VP

FORMAT (3F5.0)

One card per point, total number = NP; containing information about stress-strain and volume change data for a given σ_3 .

Col. 1-5: XP - Axial strain in percent (ϵ_1 %).

Col. 6-10: YP - Deviator stress ($\sigma_1 - \sigma_3$) corresponding to axial strain, XP.

Col. 11-15: VP - Volume strain in percent (ϵ_v %).

Note: 3rd and 4th card types are repeated NOCURVS times.

APPENDIX - I

FINLIN
PROGRAM LISTING


```

C      OVERLAY<RDY,0,0>                                FLN   1
C      OVERLAY<RDY,0,0>                                FLN   2
C      PROGRAM FINLIN (INPUT,OUTPUT,TAPE2,TAPE9,TAPE5=INPUT,TAPE6=OUTPUT,FLN   3
1TAPE1,TAPE3,TAPE4,TAPE7,TAPE10,PLOT)                FLN   4
C      THIS FINITE ELEMENT PROGRAM HAS BEEN WRITTEN FOR PH.D. THESIS FLN   5
C      PREDICTING PERFORMANCE OF PIPE CULVERTS IN SOIL FLN   6
C      BY M. B. RDY, GRADUATE RESEARCH ASSISTANT FLN   7
C      SCHOOL OF CIVIL ENGINEERING, GEOTECHNICAL ENGINEERING, FLN   8
C      PURDUE UNIVERSITY, WEST LAFAYETTE, INDIANA - 47907 FLN   9
C      DATE DECEMBER, 1975. FLN  10
C      DATE DECEMBER, 1975. FLN  11
C      COMMON NNODES,NELEMNT,NDOF,MBAND,ND,NT3,ISTOP,NCYCLE,LAYERS,ISTEP,FLN  12
1NSTEP,NT12,ETA,NT1,NT2,MOTENSH,IFLAG,NSIZE,NODDE(550),X(550),Y(550,FLN  13
2),JNDX(51),ANLISIS,IX(8,250),AREAA(250),INDX(250),INDEX(250),GAMA(2FLN  14
35),ZAI(3) FLN  15
C      COMMON /1/ E,MUE,RADIUS,XCEN,YCEN,EI,KN,KS,H1,H2,INTER FLN  16
C      COMMON /2/ D FLN  17
C      COMMON /3/ P FLN  18
C      COMMON /4/ MODU(26),DELTA FLN  19
C      COMMON /5/ D(1100),LIST(101) FLN  20
C      DIMENSION TITLE(13), R(1100), TEMP(17) FLN  21
C      DIMENSION E(10), MUE(10), D(10,10) FLN  22
C      REAL MUE FLN  23
C      REAL KN,KS FLN  24
C      THIS IS MAIN OVERLAY, WHICH DIRECTS EXECUTION OF OTHER OVERLAYS FLN  25
C      DEPENDING UPON TYPE OF ANALYSIS AND OTHER COMMANDS FLN  26
C      FOLLOWING TWO STATEMENTS ARE LIBRARY ROUTINES FOR FOR BLOCK AND STFLN  27
C      CALL FTNBRH (1,0) FLN  28
C      CALL SETSTAK (0) FLN  29
C      MAX. SIZE OF SEMI-BAND WIDTHOF TOTAL STIFFNESS MATRIX INCLUDING DIFLN  30
C      NSIZE=103 FLN  31
C      NSTEP=1 FLN  32
C      IFLAG=0 FLN  33
C      REWIND 2 FLN  34
C      READ (5,55) TITLE,MESH FLN  35
C      IF (EOF,5) 5,10 FLN  36
C      5 GO TO 40 FLN  37
10 CONTINUE FLN  38
C      CALL ZERO (R,1100) FLN  39
C      WRITE (2) (R(I),I=1,1100) FLN  40
C      ISTEP=1 FLN  41
C      WRITE (6,60) TITLE FLN  42
C      CREATE MASS STORAGE FILES FLN  43
C      INITIALISE MASS STORAGE UNITS FLN  44
C      CALL OPENMS (1,INDX,250,0) FLN  45
C      CALL OPENMS (3,INDEX,250,0) FLN  46
C      CALL OPENMS (4,NDOU,26,0) FLN  47
C      CALL OPENMS (7,JNDX,51,0) FLN  48
C      CALL OPENMS (10,LIST,1100,0) FLN  49
C      ND=NSIZE FLN  50
C      OVERLAY<1,0> READS PROBLEM GEOMETRY AND MATERIAL PROPERTIES FLN  51

```


C	CALL OVERLAY (SHRDY,1,0,6HRECALL)	FLN	60
C	IF (MESH.GT.0) CALL OVERLAY (SHRDY,2,0,6HRECALL)	FLN	61
C	CALL ZERO (TEMP,17)	FLN	62
C	DO 15 I=1,NELEINT	FLN	63
C	CALL WRITMS (1,TEMP,17,I)	FLN	64
C	15 CONTINUE	FLN	65
C		FLN	66
C	FOLLOWING PARAMETERS DESCRIBE TYPE OF ANALYSIS DESIRED	FLN	67
C	NOTENSH .GT. 0 = NO-TENSION ANALYSIS, = 0, NO CHECK FOR TENSION	FLN	68
C	INTER .GT. ZERO, = INTERACTION, INTER=0, NO INTERACTION	FLN	69
C	NSTEP = NO. OF INCREMENTS PER LAYER	FLN	70
C	H1 = STARTING HEIGHT OF THIS LAYER	FLN	71
C	H2 = ENDING HEIGHT OF THIS LAYER	FLN	72
C	KN = NORMAL STIFFNESS FOR INTERACTION	FLN	73
C	KS = SHEAR STIFFNESS FOR INTERACTION	FLN	74
C	NITER = NO. OF ITERATION SPECIFIED FOR NO-TENSION ANALYSIS	FLN	75
C		FLN	76
C		FLN	77
C	20 READ (5,65) NOTENSH,INTER,NSTEP,H1,H2,KN,KS,NITER	FLN	78
C	NCYCLE=1	FLN	79
C	WRITE (6,70) INTER,NSTEP,H1,H2,NOTENSH	FLN	80
C	25 ND=NSIZE	FLN	81
C	NCOUNT=0	FLN	82
C		FLN	83
C	FORM STRUCTURAL STIFFNESS MATRIX AND LOAD VECTOR	FLN	84
C		FLN	85
C	CALL OVERLAY (SHRDY,3,0,6HRECALL)	FLN	86
C	WRITE (6,75)	FLN	87
C		FLN	88
C	MODIFY FOR BOUNDARY CONDITIONS	FLN	89
C	SOLVE FOR DISPLACEMENT	FLN	90
C		FLN	91
C	CALL OVERLAY (SHRDY,6,0,6HRECALL)	FLN	92
C		FLN	93
C	FIND STRESSES AND STRAINS, AND PRINT RESULTS	FLN	94
C		FLN	95
C	30 CALL OVERLAY (SHRDY,4,0,6HRECALL)	FLN	96
C	CALL OVERLAY (SHRDY,5,0,6HRECALL)	FLN	97
C	IF (IFLAG.LE.0) GO TO 35	FLN	98
C		FLN	99
C	RECYCLE FOR NO-TENSION	FLN	100
C		FLN	101
C	NCOUNT=NCOUNT+1	FLN	102
C	IF (NCOUNT.GT.NITER) GO TO 50	FLN	103
C	CALL OVERLAY (SHRDY,6,0,6HRECALL)	FLN	104
C	GO TO 30	FLN	105
C		FLN	106
C	RECYCLE PROGRAM FOR INCREMENTAL OR NON-LINEAR ANALYSIS	FLN	107
C		FLN	108
C	35 NCYCLE=NCYCLE+1	FLN	109
C	IFLAG=0	FLN	110
C	IF (NCYCLE.GT.NSTEP) GO TO 40	FLN	111
C	GO TO 25	FLN	112
C	40 ISTEP=ISTEP+1	FLN	113
C	IF (ISTEP.GT.LAYERS) GO TO 45	FLN	114
C	GO TO 20	FLN	115
C	45 WRITE (6,80)	FLN	116
C		FLN	117
C	CLOSE ALL MASS STORAGE UNITS	FLN	118
C		FLN	119


```

      CALL CLOSEMS (1)          FLN 120
      CALL CLOSEMS (3)          FLN 121
      CALL CLOSEMS (4)          FLN 122
      CALL CLOSEMS (7)          FLN 123
      CALL CLOSEMS (10)         FLN 124
C
      STOP                      FLN 125
50  WRITE (6,85) NCOUNT        FLN 126
      STOP                      FLN 127
C
85  FORMAT (13A6,I2)            FLN 128
      STOP                      FLN 129
C
95  FORMAT (13A6,I2)            FLN 130
60  FORMAT (20X,13A6)           FLN 131
65  FORMAT (312,4X,2F10.0,2E10.0,I5) FLN 132
70  FORMAT (/10X, 17H LAYER INFORMATION: /10X, 14H INTERACTION = ,I5/10X, FLN 133
      1 35H NO. OF INCREMENTS FOR THIS LAYER = ,I5/10X, 32H STARTING HEIGHT FLN 134
      2 OF THIS LAYER = ,F10.2/10X, 33H FINISHING HEIGHT OF THIS LAYER = ,FLN 135
      3F10.2/10X, 14H NO-TENSIONH = ,I5/10X, 30H NO. OF ITERATIONS SPECIFIED FLN 136
      4D = ,I5//)              FLN 137
75  FORMAT (10X, 23H OVERLAY (3,0) COMPLETED) FLN 138
80  FORMAT (///5X, 15H END OF PROBLEM)      FLN 139
85  FORMAT (///10X, 45H NO-TENSION ITERATION DOES NOT CONVERGE AFTER ,I FLN 140
      15, 13H ITERATIONS, /10X, 20H EXECUTION TERMINATED) FLN 141
C
      END                      FLN 142
      SUBROUTINE ZERO (A,N)      FLN 143
      ZRO 2
C
      ZRO 3
C
      ZRO 4
      THIS SUBROUTINE GENERATES A NULL VECTOR      ZRO 5
C
      ZRO 6
C
      ZRO 7
      DIMENSION A(N)            ZRO 8
      DO 5 I=1,N                ZRO 9
        A(I)=0.0                ZRO 10
5  CONTINUE                     ZRO 11
      RETURN                    ZRO 12
C
      ZRO 13
      END                      ZRO 14
      SUBROUTINE NULLMAT (A,M,N) NUL 2
C
      NUL 3
      THIS ROUTINE GENERATES A NULL MATRIX  $\neq A \neq$  OF SIZE (M X N) NUL 4
C
      NUL 5
      DIMENSION A(M,N)          NUL 6
      DO 5 I=1,M                NUL 7
      DO 5 J=1,N                NUL 8
        A(I,J)=0.0             NUL 9
5  CONTINUE                     NUL 10
      RETURN                    NUL 11
C
      NUL 12
      END                      NUL 13
      OVERLAY(ROY,1,0)          IN1 1
C
      OVERLAY(ROY,1,0)          IN1 2
      PROGRAM INPUT             IN1 3
      COMMON /NODES, RELEMT, NDOF, NBEAM, ND, MT3, ISTOP, NCYCLE, LAYERS, ISTEP, IN1 4
      INSTEP, NT12, ETA, NT1, NT2, NOTENSH, IFLAG, NSIZE, NCODE(550), X(550), Y(550) IN1 5
      2), JNDX(51), ANALYSIS, IX(8,250), AREAAX(250), INDXX(250), INDEXX(250), GAMA(2 IN1 6
      35), ZAI(3)               IN1 7
      COMMON /1/ E, NUC, RADIUS, XCEH, YCEH, E1, KN, KS, H1, H2, INTER IN1 8
      COMMON /2/ D              IN1 9
      COMMON /4/ NDDUX(26), DELTA IN1 10
      DIMENSION EX(10), RUE(10), D(10,10) IN1 11

```


	DIMENSION TYPE(10)	IN1	12
	DIMENSION NL(4)	IN1	13
	DATA MAXNP,MAXEL,MAXMAT/350,250,25/	IN1	14
	DATA PLSTRN,PLSTRN/6HPLSTRN/	IN1	15
	REAL KZERO	IN1	16
	REAL KN,KS	IN1	17
	REAL HUE	IN1	18
	NT3=0	IN1	19
	HDOF=0	IN1	20
	MBAND=0	IN1	21
	NT1=0	IN1	22
	NT2=0	IN1	23
	NT12=0	IN1	24
C		IN1	25
C	READ PROBLEM STATEMENT AND OTHER PARAMETERS	IN1	26
C		IN1	27
	READ (5,75) NNODES,NELEMT,MATRIAL,NPRSR,LAYERS,ISTOP	IN1	28
	IF (NNODES.LE.MAXNP) GO TO 5	IN1	29
	WRITE (6,80) NNODES	IN1	30
5	IF (NELEMT.LE.MAXEL) GO TO 10	IN1	31
	WRITE (6,85) NELEMT	IN1	32
C		IN1	33
C	*****	IN1	34
C	PRINT LAYOUT OF THE PROBLEM	IN1	35
C	*****	IN1	36
C		IN1	37
10	WRITE (6,90) NNODES,NELEMT,MATRIAL,NPRSR,LAYERS	IN1	38
	IF (MATRIAL.LE.MAXMAT) GO TO 15	IN1	39
	WRITE (6,95) MATRIAL	IN1	40
15	CONTINUE	IN1	41
C		IN1	42
C	*****	IN1	43
C	READ MATERIAL TYPES, PROPERTIES AND DESCRIPTION	IN1	44
C	*****	IN1	45
C		IN1	46
	WRITE (6,105)	IN1	47
	CALL ZERO (GAMA,25)	IN1	48
	DO 20 I=1,MATRIAL	IN1	49
	READ (5,100) NTYPE,GAMA(NTYPE),TYPE	IN1	50
	WRITE (6,110) NTYPE,GAMA(NTYPE),TYPE	IN1	51
20	CONTINUE	IN1	52
	READ (5,115) ANLSIS,DELTA	IN1	53
	DO 25 I=1,MATRIAL	IN1	54
	CALL INPUT2 (I)	IN1	55
	IF (ANLSIS.EQ.PLSTRN) CALL PLNSTRN (I)	IN1	56
	IF (ANLSIS.EQ.PLSTRN) CALL PARANTR (I)	IN1	57
C		IN1	58
C	IF ISTOP.GT. ZERO, NON-LINEAR PROPERTY SPECIFIED	IN1	59
C		IN1	60
	IF (ISTOP.GT.0) CALL SPLINE (I)	IN1	61
25	CONTINUE	IN1	62
C		IN1	63
C	*****	IN1	64
C		IN1	65
	CALL ZERO (X,NNODES)	IN1	66
	CALL ZERO (Y,NNODES)	IN1	67
	CALL ZERO (HCODE,550)	IN1	68
C		IN1	69
C	READ NODAL POINT DATA, CODE, COORDINATES, LOADS, ETC.	IN1	70
C	NREAD = TOTAL NO. OF NODAL DATA CARDS SUPPLIED	IN1	71

C	FACTOR = UNIT CONVERSION FACTOR FOR NODAL COORDINATE DATA	IN1	72
C		IN1	73
	READ (5,120) NREAD,FACTOR	IN1	74
	DO 30 I=1,NREAD	IN1	75
	READ (5,125) NN,NCODE(NN),X(NN),Y(NN)	IN1	76
	IF (NCODE(NN).GT.3) NT3=NT3+1	IN1	77
	X(NN)=X(NN)*FACTOR	IN1	78
	Y(NN)=Y(NN)*FACTOR	IN1	79
30	CONTINUE	IN1	80
C		IN1	81
C	*****	IN1	82
C	READ ELEMENT DATA, TYPE, MATERIAL	IN1	83
C		IN1	84
	CALL NULLMAT (IX,8,NELEMT)	IN1	85
	CALL ZERO (AREAR,NELEMT)	IN1	86
	DO 35 I=1,NELEMT	IN1	87
	READ (5,130) IEL,(IX(J,IEL),J=1,8)	IN1	88
	NT=IX(7,IEL)	IN1	89
	IF (NT.EQ.1) NT1=NT1+1	IN1	90
	IF (NT.EQ.2) NT2=NT2+1	IN1	91
35	CONTINUE	IN1	92
	NT12=NT1+NT2	IN1	93
C		IN1	94
C	WRITE NODAL POINT INFORMATIONS	IN1	95
C		IN1	96
	WRITE (6,135)	IN1	97
	DO 40 J=1,NNODES	IN1	98
	WRITE (6,140) J,NCODE(J),X(J),Y(J)	IN1	99
40	CONTINUE	IN1	100
C		IN1	101
C	WRITE ELEMENT INFORMATIONS	IN1	102
C		IN1	103
	WRITE (6,145)	IN1	104
	DO 45 I=1,NELEMT	IN1	105
	WRITE (6,150) I,(IX(J,I),J=1,8)	IN1	106
45	CONTINUE	IN1	107
	READ (5,160) ZAI(1),ZAI(2),ZAI(3)	IN1	108
	WRITE (6,155) ZAI(1),ZAI(2),ZAI(3)	IN1	109
C		IN1	110
C	DETERMINE BAND WIDTH	IN1	111
C		IN1	112
C	DETERMINE NODAL FORCES DUE TO SELF WEIGHT, FOR THIS PURPOSE	IN1	113
C		IN1	114
	WRITE (6,165)	IN1	115
	DO 65 II=1,NELEMT	IN1	116
	NT=IX(7,II)	IN1	117
	GO TO (50,55,60,60,60), NT	IN1	118
50	I1=IX(1,II)	IN1	119
	I2=IX(2,II)	IN1	120
	IDF=I1-I2	IN1	121
	NBAND=(ABS(IDF)+1)*3	IN1	122
	IF (NBAND.GT.NBAND) NBAND=NBAND	IN1	123
	GO TO 65	IN1	124
55	I1=IX(1,II)	IN1	125
	I2=IX(2,II)	IN1	126
	I3=IX(3,II)	IN1	127
	I4=IX(4,II)	IN1	128
	NL(1)=3*I1-2	IN1	129
	NL(2)=3*I2-2	IN1	130
	NL(3)=2*I3-1+NT3	IN1	131

	NL(4)=2*I4-1+NT3	IN1	132
	MAX=MAX0(NL(1),NL(2),NL(3),NL(4))	IN1	133
	MIN=MIN0(NL(1),NL(2),NL(3),NL(4))	IN1	134
	NBAND=MAX-MIN+2	IN1	135
	IF (NBAND.GT.MBAND) MBAND=NBAND	IN1	136
	GO TO 65	IN1	137
60	CALL AREAS (II,NT)	IN1	138
65	CONTINUE	IN1	139
	NDOF=2*NNODES+NT3	IN1	140
C		IN1	141
C	PRINT SIZE OF THE PROBLEM	IN1	142
C		IN1	143
	WRITE (6,170) NDOF,MBAND	IN1	144
C		IN1	145
	IF (NT3.LE.0) GO TO 70	IN1	146
C		IN1	147
C	READ CENTER, RADIUS, AND EI OF PIPE	IN1	148
C		IN1	149
	READ (5,175) XCEN,YCEN,RADIUS,EI	IN1	150
	WRITE (6,180) XCEN,YCEN,RADIUS,EI	IN1	151
C		IN1	152
C	DETERMINE ETA FOR TRIANGULAR ELEMENTS	IN1	153
C		IN1	154
	NT12P1=NT12+1	IN1	155
	IF (NT12P1.GT.NELEMNT) GO TO 70	IN1	156
	I1=IX(1,NT12P1)	IN1	157
	I2=IX(2,NT12P1)	IN1	158
	X1=X(I1)	IN1	159
	Y1=Y(I1)	IN1	160
	X2=X(I2)	IN1	161
	Y2=Y(I2)	IN1	162
	SPAN=SQRT((X1-X2)**2+(Y1-Y2)**2)	IN1	163
	SH=0.5*SPAN/RADIUS	IN1	164
	TH=ASIN(SH)	IN1	165
	THETA=2.*TH	IN1	166
	R2=RADIUS**2	IN1	167
	A1=0.5*THETA*R2	IN1	168
	A2=0.5*R2*SIN(THETA)	IN1	169
	A4=A1-A2	IN1	170
	ETA=A4/APEAA(NT12P1)	IN1	171
	ETA=0.0	IN1	172
C		IN1	173
	70 CONTINUE	IN1	174
	WRITE (6,185)	IN1	175
	RETURN	IN1	176
C		IN1	177
	75 FORMAT (2I5,2I3,2X,I2,2X,I2,1X,I1,1X,I2)	IN1	178
	80 FORMAT (5X, 42HNO. OF NODES EXCEEDS LIMIT(=900), NNODES=, I5)	IN1	179
	85 FORMAT (5X, 46HNO. OF ELEMENTS EXCEEDS LIMIT(=500), NELEMNT=, I5)	IN1	180
	90 FORMAT (10X, 19HPROBLEM DESCRIPTION, //5X, 19HNO. OF NODE POINTS=, I1N1	IN1	181
	15/5X, 16HNO. OF ELEMENTS=, I5/5X, 17HNO. OF MATERIALS=, I5/5X, 26HNOIN1	IN1	182
	2. OF BOUNDARY PRESSURES=, I5/5X, 29HNO. OF CONSTRUCTION LAYERS =, I1N1	IN1	183
	35//)	IN1	184
	95 FORMAT (5X, 47HNO. OF MATERIALS EXCEEDS LIMIT (= 25), MATRIAL=, I5)IN1	IN1	185
	100 FORMAT (15,F10.0,10A6)	IN1	186
	105 FORMAT (///10X, 21HMATERIAL DESCRIPTIONS, //5X, 3HNO., 5X, 11HUNIT	IN1	187
	1WEIGHT, 10X, 11HDESCRIPTION, //)	IN1	188
	110 FORMAT (5X, I2, 8X, F8.4, 10X, 10A6)	IN1	189
	115 FORMAT (A6, F5.0)	IN1	190
	120 FORMAT (15, F10.0)	IN1	191


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125 FORMAT (I5,5X,I2,F10.0,20X,F10.0) IN1 192
130 FORMAT (I3,2X,2(3I5,5X),4X,I1,3X,I2,2F5.0,5X,2F5.0) IN1 193
135 FORMAT (///10X, 16HNODAL POINT DATA,///5X, 8HNODE NO.,2X, 9HDIRECIN1 194
17IDIR,3X, 10HFIXED/FREE,5X, 11HCO-ORDINATE,5X, 10HNODAL LOAD,2X, 9IN1 195
2HDIRECTION,3X, 10HFIXED/FREE,5X, 11HCO-ORDINATE,5X, 10HNODAL LOAD,IN1 196
3/) IN1 197
140 FORMAT (7X,I4,8X, 1HX,10X,I1,11X,F8.2,24X, 1HY,22X,F8.2) IN1 198
145 FORMAT (///10X, 18HELEMENT DATA INPUT,///1X, 11HELEMENT NO.,2X, 59HIN1 199
1 -P- -Q- -R- -S- -PQ- -QR- -RP- -RS- TYPE MATERIAL,///) IN1 200
150 FORMAT (2X,I5,6X,3(I3,2X),5X,3(I4,2X),6X,2X,I2,5X,I3,4X,F6.1,2X,F6IN1 201
1.2,1X,F4.0,1X,F4.0) IN1 202
155 FORMAT (10X, 9HZAI(1) = ,F5.2,5X, 9HZAI(2) = ,F5.2,5X, 9HZAI(3)IN1 203
1 = ,F5.2/) IN1 204
160 FORMAT (3F10.0) IN1 205
165 FORMAT (/10X, 20HELEMENT INFORMATIONS,/,1X, 7HELE.NO.,9X, 6HZAI(1)IN1 206
1),9X, 6HZAI(2),9X, 6HZAI(3),10X, 4HAREA,5X, 24HX-COORDINATE,Y-CIN1 207
2ORDINATE,/) IN1 208
170 FORMAT (///10X, 12HPROBLEM SIZE,///25X, 27HNO. OF DEGREES OF FREEDOMIN1 209
1M =,15/35X, 17HSEMI-BAND-WIDTH =,15/) IN1 210
175 FORMAT (3F10.0,E10.0) IN1 211
180 FORMAT (/10X, 19HPIPE SPECIFICATIONS,/,10X, 11HX-CENTER = ,F6.2,3X,IN1 212
1 11HY-CENTER = ,F6.2,/,10X, 14HPIPE RADIUS = ,F6.2,/,10X, 15HPIPE STIN1 213
2IFFNESS ,E12.2/) IN1 214
185 FORMAT (1X, 23HDOVERLAY (1,0) COMPLETED) IN1 215
C IN1 216
END IN1 217
SUBROUTINE INPUT2 (II) IN2 2
COMMON /1/ E,HUE,RADIUS,XCEN,YCEN,EI,KN,KS,H1,H2,INTER IN2 3
DIMENSION E(10), NUC(10) IN2 4
REAL KN,KS IN2 5
C IN2 6
C ***** IN2 7
C THIS ROUTINE READS DATA AND NECESSARY VARIATIONAL PARAMETERS FOR IN2 8
C MATERIAL PROPERTIES AND CONSTITUTIVE RELATIONSHIP. IN2 9
C THIS ROUTINE IS DIRECTLY CONNECTED TO #PARAMTR # THROUGH COMMON IN2 10
C IN2 11
REAL HUE IN2 12
C IN2 13
C READ E , HUE FOR FIXED PROPERTY IN2 14
C IN2 15
READ (5,5) E(II) IN2 16
READ (5,10) NUC(II) IN2 17
WRITE (6,15) II,E(II),NUC(II) IN2 18
RETURN IN2 19
C IN2 20
5 FORMAT (10E8.0) IN2 21
10 FORMAT (F5.0) IN2 22
15 FORMAT (////10X, 27HPROPERTIES FOR MATERIAL NO ,15,/,5X, 15HYOUNGSIIN2 23
1 MODULUS=,1X,E11.4/5X, 15HPOISSONS RATIO=,F5.2) IN2 24
C IN2 25
END IN2 26
SUBROUTINE PLNSTRS (K) PLS 2
COMMON /1/ E,HUE,RADIUS,XCEN,YCEN,EI,KN,KS,H1,H2,INTER PLS 3
COMMON /2/ D PLS 4
REAL HUE,HUEK PLS 5
REAL KN,KS PLS 6
DIMENSION D(10,10), E(10), NUC(10) PLS 7
C PLS 8
C THIS ROUTINE IS FOR PLANE STRESS PLS 9
C PLS 10

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	NUEK=NUE(K)	PLS	11
	C=E(K)/(1.-NUEK*NUEK)	PLS	12
	D(K,8)=0.0	PLS	13
	D(K,7)=D(K,8)	PLS	14
	D(K,6)=D(K,7)	PLS	15
	D(K,3)=D(K,6)	PLS	16
	D(K,5)=0	PLS	17
	D(K,1)=D(K,5)	PLS	18
	D(K,4)=C*NUEK	PLS	19
	D(K,2)=D(K,4)	PLS	20
	D(K,9)=0.5*C*(1.-NUEK)	PLS	21
	D(K,10)=NUEK	PLS	22
	RETURN	PLS	23
C	END	PLS	24
	SUBROUTINE PARAMTR (K)	PLN	2
	COMMON /1/ E, NUE, RADIUS, XCEN, YCEN, EI, KN, KS, H1, H2, INTER	PLN	3
	COMMON /2/ D	PLN	4
	REAL KN, KS	PLN	5
C		PLN	6
C	THIS ROUTINE IS FOR PLANE STRAIN	PLN	7
C		PLN	8
	REAL NUE, NUEK	PLN	9
	DIMENSION D(10,10), E(10), NUE(10)	PLN	10
	NUEK=NUE(K)	PLN	11
	C=(E(K)*(1.-NUEK))/(1.+NUEK)*(1.-2.*NUEK)	PLN	12
	D(K,5)=0	PLN	13
	D(K,1)=D(K,5)	PLN	14
	D(K,4)=C*NUEK/(1.-NUEK)	PLN	15
	D(K,2)=D(K,4)	PLN	16
	D(K,9)=C*(1.-2.*NUEK)/(2.*(1.-NUEK))	PLN	17
	D(K,8)=0.0	PLN	18
	D(K,7)=D(K,8)	PLN	19
	D(K,6)=D(K,7)	PLN	20
	D(K,3)=D(K,6)	PLN	21
	D(K,10)=NUEK	PLN	22
	RETURN	PLN	23
C		PLN	24
	END	PLN	25
	SUBROUTINE AREAS (MM,NT)	ARE	2
	COMMON /NNODES, NELEMT, NDUF, MEAND, ND, NT3, ISTDF, NCYCLE, LAYERS, ISTEP, ARE	ARE	3
	1NSTEP, NT12, ETA, NT1, NT2, NTENSH, IFLAG, NSIZE, NCODE(550), X(550), Y(550)	ARE	4
	ARE(2), JNDX(51), ANLSIS, IX(8,250), AREA(250), INDX(250), INDEX(250), GAMMA(2	ARE	5
	35), ZAI(3)	ARE	6
	DIMENSION LM(6)	ARE	7
C		ARE	8
C	*****	ARE	9
C	THIS ROUTINE CALCULATES ELEMENT AREA, AND SEMI BAND WIDTH	ARE	10
C		ARE	11
	AREA=0.0	ARE	12
	I=IX(1,MM)	ARE	13
	J=IX(2,MM)	ARE	14
	K=IX(3,MM)	ARE	15
	MK=NT-2	ARE	16
	GO TO (5,15,20), MK	ARE	17
	5 DO 10 N=1,6	ARE	18
10	LM(N)=2*IX(N,MM)-NT3-1	ARE	19
	GO TO 30	ARE	20
15	LM(1)=3*IX(1,MM)-2	ARE	21
	LM(2)=3*IX(2,MM)-2	ARE	22


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      LM(3)=2*IX(3,MN)-1+NT3      ARE 23
      LM(4)=2*IX(4,MN)-2          ARE 24
      LM(5)=2*IX(5,MN)-1+NT3      ARE 25
      LM(6)=2*IX(6,MN)-1+NT3      ARE 26
      GO TO 30                     ARE 27
20 DO 25 N=1,6                   ARE 28
25 LM(N)=2*IX(N,MN)-1+NT3        ARE 29
      LM(3)=2*IX(3,MN)-2          ARE 30
30 AREA=ABS(.5*(X(J)*Y(K)-Y(J)*X(K)+X(I)*(Y(J)-Y(K))+Y(I)*(X(K)-X(J)))ARE 31
      1))                          ARE 32
      MAX=MAX0(LM(1),LM(2),LM(3),LM(4),LM(5),LM(6)) ARE 33
      MIN=MIN0(LM(1),LM(2),LM(3),LM(4),LM(5),LM(6)) ARE 34
      NWIDTH=MAX-MIN+2            ARE 35
      IF (NWIDTH.GT.MBAND) MBAND=NWIDTH ARE 36
      IF (NWIDTH.GT.ND) WRITE (6,40) NWIDTH,MN ARE 37
      IF (AREA.GT.0.0) GO TO 35    ARE 38
      WRITE (6,45) MN             ARE 39
      RETURN                      ARE 40
C                                ARE 41
35 XX=ZAI(1)*X(I)+ZAI(2)*X(J)+ZAI(3)*X(K) ARE 42
      YY=ZAI(1)*Y(I)+ZAI(2)*Y(J)+ZAI(3)*Y(K) ARE 43
      AREAR(MN)=AREA              ARE 44
      WRITE (6,50) MN,(ZAI(I),I=1,3),AREA,XX,YY ARE 45
      RETURN                      ARE 46
C                                ARE 47
40 FORMAT (3X, 32HEBANDWIDTH EXCEEDS LIMIT; MBAND= ,I5,X, 17HIN ELEMARE 48
      INT NO. = ,I5)             ARE 49
45 FORMAT (5X, 35HNEGATIVE OR ZERO AREA; ELEMENT NO.=,I5) ARE 50
50 FORMAT (2X,I5,X,4E14.2,2F12.2) ARE 51
C                                ARE 52
      END                         ARE 53
      SUBROUTINE SPLINE (IMAT)    SPL 2
      COMMON /4/ MODU(26),DELTA  SPL 3
      DIMENSION XP(7), EP(11,7), SEP(11,7), PSNR(11,7), SPSNR(11,7) SPL 4
      DIMENSION PRDP(319), SRD(11) SPL 5
C                                SPL 6
      SPLINE FITTING FOR TAN. MOD; TAN. POISSON RATIO VS; SIGMAOCTA SPL 7
C                                SPL 8
      NP= NO. OF DATA POINTS FOR STRESS SPL 8
C                                SPL 9
      PHI= FRICTION ANGLE FOR SOIL (DEGREES) SPL 9
C                                SPL 10
      PSI= RATIO OF (SIGMA2)/(SIGMA1+SIGMA3) FOR PLANE STRAIN SPL 10
C                                SPL 11
      ANISO= DEGREE OF ANISOTROPY OF SOIL STRENGTH SPL 11
C                                SPL 12
      FOR ISOTROPIC MATERIAL ANISO=1. SPL 12
C                                SPL 13
      DELTA= ANGLE OF FRICTION ( DEGREES ) BETWEEN SOIL AND PIPE SPL 13
C                                SPL 14
      FACTOR= STRENGTH PROPERTY CONVERSION FACTOR SPL 14
C                                SPL 15
      READ (5,55) NP,PSI,PHI,ANISO,DELTA,FACTOR SPL 16
      IF (ANISO.LE.0.0) ANISO=.10 SPL 17
      FRATIO=FAILURE(PSI,PHI)     SPL 18
C                                SPL 19
C                                SPL 20
      XP= OCTAH. ADPAL. NORMAL STRESS VECTOR SPL 20
C                                SPL 21
      IP= TANGENT MODULUS SPL 21
C                                SPL 22
      PSNR= TANGENT POISSONS RATIO SPL 22
C                                SPL 23
      READ (5,65) (XP(I),I=1,NP) SPL 24
      DO 5 I=1,NP                 SPL 25
5  XP(I)=FACTOR*XP(I)            SPL 26
      DO 15 ND=1,11               SPL 27
      READ (5,70) (EP(ND,J),PSNR(ND,J),J=1,NP) SPL 28
      SRD(ND)=(11.-FLDAT(ND,))/10. SPL 29
      DO 10 J=1,NP                SPL 30

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10   EP(ND,J)=FACTOR*EP(ND,J)                                SPL 31
C                                         SPL 32
C       CUBIC SPLINE FITTING FOR TANGENT MODULUS AND POISSONS RATIO    SPL 33
C                                         SPL 34
C       CALL SPLFIT (NP,ND,XP,EP,SEP)                          SPL 35
C       CALL SPLFIT (NP,ND,XP,PSNR,SPSNR)                      SPL 36
15  CONTINUE                                                  SPL 37
    WRITE (6,75) IMAT                                         SPL 38
    WRITE (6,80) PHI,PSI,FRATIO,DELTA,ANISO                   SPL 39
    WRITE (6,80) (XP(I),I=1,NP)                               SPL 40
    WRITE (6,85) (SRD(I),I=1,11)                               SPL 41
    DO 20 I=1,NP                                              SPL 42
20  WRITE (6,90) (EP(J,I),J=1,11)                             SPL 43
    WRITE (6,95) (SRD(I),I=1,11)                             SPL 44
    DO 25 I=1,NP                                              SPL 45
25  WRITE (6,90) (PSNR(J,I),J=1,11)                           SPL 46
C                                         SPL 47
C       STORE MATERIAL PROPERTIES ON MASS STORAGE UNIT          SPL 48
C                                         SPL 49
    PROP(1)=ANISO                                             SPL 50
    PROP(2)=DELTA                                             SPL 51
    PROP(3)=FRATIO                                           SPL 52
    MD=3                                                       SPL 53
    DO 30 I=1,7                                               SPL 54
        MD=MD+1                                               SPL 55
30  PROP(MD)=XP(I)                                           SPL 56
    DO 35 I=1,11                                              SPL 57
        DO 35 J=1,7                                           SPL 58
            MD=MD+1                                           SPL 59
35  PROP(MD)=EP(I,J)                                         SPL 60
    DO 40 I=1,11                                              SPL 61
        DO 40 J=1,7                                           SPL 62
            MD=MD+1                                           SPL 63
40  PROP(MD)=SEP(I,J)                                         SPL 64
    DO 45 I=1,11                                              SPL 65
        DO 45 J=1,7                                           SPL 66
            MD=MD+1                                           SPL 67
45  PROP(MD)=PSNR(I,J)                                       SPL 68
    DO 50 I=1,11                                              SPL 69
        DO 50 J=1,7                                           SPL 70
            MD=MD+1                                           SPL 71
50  PROP(MD)=SPSNR(I,J)                                       SPL 72
    PROP(319)=FLOAT(NP)                                       SPL 73
    CALL WRITMS (4,PROP,319,MAT)                             SPL 74
    RETURN                                                    SPL 75
C                                         SPL 76
55  FORMAT (I5,5F10.0)                                       SPL 77
60  FORMAT (1X, 24HFAILURE RATIO FOR PHI = ,F6.2, 12H  AND PSI = ,F5.2,SPL 78
    1, 8H IS = ,F6.3/10X, 8HDELTA = ,F6.2, 22H  ANISOTROPY FACTOR =SPL 79
    2, F6.2/ )                                              SPL 80
65  FORMAT (8F10.0)                                           SPL 81
70  FORMAT (2F10.0)                                           SPL 82
75  FORMAT (/10X, 45HNON-LINEAR SOIL PROPERTIES FOR MATERIAL NO = ,I5)SPL 83
80  FORMAT (1X, 11HSIGMA(OCT)=,12E9.1)                       SPL 84
85  FORMAT (10X, 22HTANGENT MODULUS VALUES,/2X, 15HSTRESS RATIO = ,F3.SPL 85
    11,10(6X,F3.1)/ )                                       SPL 86
90  FORMAT (15X, 11E9.2)                                       SPL 87
95  FORMAT (/10X, 28HTANGENT POISSON RATIO VALUES,/2X, 15HSTRESS RATIO SPL 88
    10 = ,F3.1,10(6X,F3.1)/ )                               SPL 89
C                                         SPL 90

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	END	SPL	91
	SUBROUTINE SPLFIT (NPN,ND,XP,YP,YDP)	SPF	2
	DIMENSION XP(7), YP(11,7), YDP(11,7), H(7), Y(7), AI(7), BI(7), CISP(7), DI(7), SDP(7)	CISP	3
		SPF	4
C		SPF	5
C		SPF	6
C	CUBIC SPLINE FITTING	SPF	7
	NP1=NPN-1	SPF	8
	DO 5 M=1,NP1	SPF	9
5	H(M)=XP(M+1)-XP(M)	SPF	10
	SLOP1=F(D(H(1),H(2),YP(ND,1),YP(ND,2),YP(ND,3))	SPF	11
	SLOPN=BD(H(NPN-2),H(NPN-1),YP(ND,NPN-2),YP(ND,NPN-1),YP(ND,NPN))	SPF	12
	DO 10 M=1,NPN	SPF	13
10	Y(M)=YP(ND,M)	SPF	14
	CALL COFRIT (NPN,XP,Y,SLOP1,SLOPN,AI,BI,CI,DI)	SPF	15
	CALL TRIDGNL (NPN,AI,BI,CI,DI,SDP)	SPF	16
	DO 15 I=1,NPN	SPF	17
15	YDP(ND,I)=SDP(I)	SPF	18
	RETURN	SPF	19
C		SPF	20
	END	SPF	21
	SUBROUTINE COFRIT (NPN,XP,YP,SLOP1,SLOPN,AI,BI,CI,DI)	COF	2
	DIMENSION XP(7), YP(7), AI(7), BI(7), CI(7), DI(7)	COF	3
C		COF	4
C		COF	5
C	GENERATE SPLINE COEFFICIENTS	COF	6
	AI(1)=0.0	COF	7
	BI(1)=(XP(2)-XP(1))/3.	COF	8
	CI(1)=BI(1)/2.	COF	9
	DI(1)=(YP(2)-YP(1))/(XP(2)-XP(1))-SLOP1	COF	10
	AI(NPN)=(XP(NPN)-XP(NPN-1))/6.	COF	11
	BI(NPN)=AI(NPN)*2.	COF	12
	CI(NPN)=0.0	COF	13
	DI(NPN)=-(YP(NPN)-YP(NPN-1))/(XP(NPN)-XP(NPN-1))+SLOPN	COF	14
	N1=NPN-1	COF	15
	DO 5 I=2,N1	COF	16
	AI(I)=(XP(I)-XP(I-1))/6.	COF	17
	BI(I)=(XP(I+1)-XP(I-1))/3.	COF	18
	CI(I)=(XP(I+1)-XP(I))/6.	COF	19
	DI(I)=(YP(I+1)-YP(I))/(XP(I+1)-XP(I))-(YP(I)-YP(I-1))/(XP(I)-XP(I-1))	COF	20
	1 (I-1)	COF	21
5	CONTINUE	COF	22
	RETURN	COF	23
C		COF	24
	END	COF	25
	SUBROUTINE TRIDGNL (NPN,AI,BI,CI,DI,YDP)	TRI	2
	DIMENSION AI(7), BI(7), CI(7), DI(7), YDP(7), Q(10), U(10)	TRI	3
C		TRI	4
C	SOLVE TRI-DIAGONAL MATRIX	TRI	5
C		TRI	6
	P=BI(1)	TRI	7
	Q(1)=-CI(1)/P	TRI	8
	U(1)=DI(1)/P	TRI	9
	DO 5 K=2,NPN	TRI	10
	P=AI(K)*Q(K-1)+BI(K)	TRI	11
	Q(K)=-CI(K)/P	TRI	12
	U(K)=(DI(K)-AI(K)*U(K-1))/P	TRI	13
5	CONTINUE	TRI	14
	YDP(NPN)=U(NPN)	TRI	15
	N1=NPN-1	TRI	16

DO 10 L=1,N1	TRI	17
K=N1+1-L	TRI	18
YDF(K)=Q(K)*YDF(K+1)+U(K)	TRI	19
10 CONTINUE	TRI	20
RETURN	TRI	21
C	TRI	22
END	TRI	23
FUNCTION FD(S1,S2,R1,R2,R3)	FD	2
C	FD	3
C	FD	4
C	FD	5
IF (S1-S2) 5,10,5	FD	6
5 FD=(R2-R1)/S1	FD	7
RETURN	FD	8
10 FD=(-3.*R1+4.*R2-R3)/(2.*S1)	FD	9
RETURN	FD	10
C	FD	11
END	FD	12
FUNCTION BD(S1,S2,R1,R2,R3)	BD	2
C	BD	3
C	BD	4
C	BD	5
IF (S1-S2) 5,10,5	BD	6
5 BD=(R3-R2)/S2	BD	7
RETURN	BD	8
10 BD=(3.*R3-4.*R2+R1)/(2.*S1)	BD	9
RETURN	BD	10
C	BD	11
END	BD	12
FUNCTION ORDINET(A,B,C,D,E,F,P)	ORD	2
HJ=D-C	ORD	3
B1=D-P	ORD	4
B2=P-C	ORD	5
A1=B1**3	ORD	6
A2=B2**3	ORD	7
T1=A1*A/(6.*HJ)	ORD	8
T2=A2*B/(6.*HJ)	ORD	9
T3=(E-A*HJ**2/6.)*(D-P)/HJ	ORD	10
T4=(F-B*HJ**2/6.)*(P-C)/HJ	ORD	11
ORDINET=T1+T2+T3+T4	ORD	12
RETURN	ORD	13
C	ORD	14
END	ORD	15
FUNCTION FAILURE(PSI,PHI)	FR	2
C	FR	3
C	FR	4
C	FR	5
REAL NPHI	FR	6
P1=22./7.	FR	7
PHI=PHI1*PI/180.	FR	8
SINPHI=SIN(PHI)	FR	9
NPHI=(1.+SINPHI)/(1.-SINPHI)	FR	10
T1=6.*NPHI/(NPHI+1.)**2	FR	11
T2=2.*(PSI**2-PSI+1.)	FR	12
T3=SQRT(T2-T1)	FR	13
T4=T3/(1.+PSI)	FR	14
FAILURE=T4	FR	15
RETURN	FR	16
C	FR	17
END	FR	18

	OVERLAY (RBY,2,0)	PLT	1
C	PROGRAM LAYOUT	PLT	2
	COMMON NHDIES,NELEMNT,NDDF,NBAND,ND,NT3,ISTOP,NCYCLE,LAYERS,ISTEP,PLT	PLT	3
	1,ISTEP,NT12,ETA,NT1,NT2,NITEHSN,IFLAG,NSIZE,NODE(550),X(550),Y(550)	PLT	4
	PLT 2),JNDX(51),AHLIS(,IX(8,250),AREA(250),INDX(250),INDEX(250),GAMA(2	PLT	5
	35),ZAI(3)	PLT	6
	DIMENSION XPOLY(6), YPOLY(6)	PLT	7
	CALL PLOTS	PLT	8
	READ (5,25) XMAX,YMAX,YCEN	PLT	9
	SF=10./YMAX	PLT	10
	CALL FACTOR (SF)	PLT	11
	CALL PLOT (0,0,0,0,-3)	PLT	12
	YPOLY(4)=0.0	PLT	13
	XPOLY(4)=YPOLY(4)	PLT	14
	YPOLY(5)=1.0	PLT	15
	XPOLY(5)=YPOLY(5)	PLT	16
	CALL AXIS (0,0,0,0,2HX,-2,XMAX,0,0,XPOLY(4),XPOLY(5),0)	PLT	17
	CALL AXIS (0,0,0,0,2HY,-2,YMAX,90,0,YPOLY(4),YPOLY(5),-1)	PLT	18
	CALL PLOT (0,0,YMAX,3)	PLT	19
	CALL PLOT (XMAX,YMAX,2)	PLT	20
	CALL PLOT (XMAX,0,0,2)	PLT	21
	DO 20 I=1,NELEMNT	PLT	22
	NT=IX(7,I)	PLT	23
	GO TO (5,10,15), NT	PLT	24
5	I1=IX(2,I)	PLT	25
	I2=IX(1,I)	PLT	26
	XPOLY(1)=X(I1)	PLT	27
	YPOLY(1)=Y(I1)	PLT	28
	XPOLY(2)=X(I2)	PLT	29
	YPOLY(2)=Y(I2)	PLT	30
	YPOLY(3)=0.0	PLT	31
	XPOLY(3)=YPOLY(3)	PLT	32
	YPOLY(4)=1.0	PLT	33
	XPOLY(4)=YPOLY(4)	PLT	34
	CALL LINE (XPOLY,YPOLY,2,1,0,0)	PLT	35
10	GO TO 20	PLT	36
15	CONTINUE	PLT	37
	I1=IX(1,1)	PLT	38
	I2=IX(2,1)	PLT	39
	I3=IX(3,1)	PLT	40
	XPOLY(4)=X(I1)	PLT	41
	XPOLY(1)=XPOLY(4)	PLT	42
	YPOLY(4)=Y(I1)	PLT	43
	YPOLY(1)=YPOLY(4)	PLT	44
	XPOLY(2)=X(I2)	PLT	45
	YPOLY(2)=Y(I2)	PLT	46
	XPOLY(3)=X(I3)	PLT	47
	YPOLY(3)=Y(I3)	PLT	48
	YPOLY(5)=0.0	PLT	49
	XPOLY(5)=YPOLY(5)	PLT	50
	YPOLY(6)=1.0	PLT	51
	XPOLY(6)=YPOLY(6)	PLT	52
	CALL LINE (XPOLY,YPOLY,4,1,0,0)	PLT	53
	XC=(X(I1)+X(I2)+X(I3))/3.-0.2	PLT	54
	YC=(Y(I1)+Y(I2)+Y(I3))/3.	PLT	55
	CALL NUMBER (XC,YC,0.4,1,0,0,2H13)	PLT	56
20	CONTINUE	PLT	57
	XC=XMAX/2.-2.	PLT	58
	YC=YMAX+2.	PLT	59
		PLT	60

	CALL SYMBOL (0,0,YCEN,0,3,11,0,0,-1)	PLT	61
	CALL SYMBOL (XC,YC,0,6,1,INFINITE ELEMENT MESH,0,0,19)	PLT	62
	CALL PLOT (0,0,0,0,999)	PLT	63
	RETURN	PLT	64
C		PLT	65
	25 FORMAT (3F10.0)	PLT	66
C		PLT	67
	END	PLT	68
	OVERLAY(CROY,3,0)	BLK	1
C		BLK	2
	OVERLAY(CROY,3,0)	BLK	3
	PROGRAM BLOCK	BLK	4
	COMMON NNODES,NELEMNT,NDHIF,NBAND,ND,NT3,ISTOP,NCYCLE,LAYERS,ISTEP,BLK	BLK	5
	1NSTEP,NT12,ETA,NT1,NT2,NUTENSH,IFLAG,NSIZE,NODE(550),X(550),Y(550),BLK	BLK	6
	2),JNDX(51),ANLSIS,IX(8,250),AREAA(250),INDX(250),INDEX(250),GAMA(2,BLK	BLK	7
	35),ZAI(3)	BLK	8
	COMMON /1/ E,HUE,RADIUS,XCEN,YCEN,EI,KN,KS,H1,H2,INTER	BLK	9
	COMMON /3/ P	BLK	10
	COMMON /4/ MODU(26),DELTA	BLK	11
	COMMON /5/ O(1100),LIST(101)	BLK	12
	DIMENSION R(1100),TEMP(17),LM(6),SK(12,12)	BLK	13
	DIMENSION XP(7),EP(11,7),SEP(11,7),PSHR(11,7),SPSNR(11,7)	BLK	14
	DIMENSION E(10),NUE(10),PRDP(319)	BLK	15
	DIMENSION A(103,103),AREAY(103)	BLK	16
	DIMENSION SR(6,6),SKJT(8,8)	BLK	17
	DIMENSION TEMP(17)	BLK	18
	REAL NUEX,NUFY	BLK	19
	REAL KN,KS	BLK	20
	REAL HUE	BLK	21
	PI=22./7.	BLK	22
	ANISO=1.0	BLK	23
	NDINC=1	BLK	24
	IF (NT3.LE.0) NDINC=0	BLK	25
	IF (NT3.LE.0) ND=ND-1	BLK	26
	NEND=3*NT3	BLK	27
	ND2=2*ND	BLK	28
	NDOF=2*NNODES+NT3	BLK	29
	CALL NULLMAT (A,NSIZE,NSIZE)	BLK	30
	CALL NULLMAT (SK,12,12)	BLK	31
	CALL ZERO (0,NDOF)	BLK	32
C		BLK	33
C	FIND NODAL LOADS FOR ELEMENTS IN THIS PARTICULAR LAYER	BLK	34
C		BLK	35
	DO 40 II=1,NELEMNT	BLK	36
	NT=IX(7,II)	BLK	37
	GO TO (40,40,5,5,5), NT	BLK	38
5	I1=IX(1,II)	BLK	39
	I2=IX(2,II)	BLK	40
	I3=IX(3,II)	BLK	41
	YC=(Y(I1)+Y(I2)+Y(I3))/3.	BLK	42
	IF (YC.GT.H2.OR.YC.LE.H1) GO TO 40	BLK	43
	NT=IX(8,II)	BLK	44
	NT=GAMA(NT)*AREAA(II)	BLK	45
	MK=NT-2	BLK	46
	GO TO (10,20,25), MK	BLK	47
10	DO 15 I=1,6	BLK	48
15	LM(I)=2*IX(I,II)+NT3	BLK	49
	GO TO 35	BLK	50
20	LM(1)=3*IX(1,II)-1	BLK	51
	LM(2)=3*IX(2,II)-1	BLK	52
	LM(3)=2*IX(3,II)+NT3	BLK	

	LM(4)=3*IX(4, I1)-1	BLK	53
	LM(5)=2*IX(5, I1)+NT3	BLK	54
	LM(6)=2*IX(6, I1)+NT3	BLK	55
	DO 30 I=1,6	BLK	56
25	DO 30 I=1,6	BLK	57
30	LM(1)=2*IX(1, I1)+NT3	BLK	58
	LM(3)=3*IX(3, I1)-1	BLK	59
35	I1=LM(1)	BLK	60
	I2=LM(2)	BLK	61
	I3=LM(3)	BLK	62
	I4=LM(4)	BLK	63
	I5=LM(5)	BLK	64
	I6=LM(6)	BLK	65
	Q(I1)=Q(I1)-WT/12.	BLK	66
	Q(I2)=Q(I2)-WT/12.	BLK	67
	Q(I3)=Q(I3)-WT/12.	BLK	68
	Q(I4)=Q(I4)-WT/4.	BLK	69
	Q(I5)=Q(I5)-WT/4.	BLK	70
	Q(I6)=Q(I6)-WT/4.	BLK	71
40	CONTINUE	BLK	72
	DO 45 I=1,NDOP	BLK	73
45	Q(I)=Q(I)/FLOAT(NSTEP)	BLK	74
C		BLK	75
	REINID 9	BLK	76
C		BLK	77
C	FORM STIFFNESS MATRIX IN BLOCKS	BLK	78
C		BLK	79
	IMAT=0	BLK	80
	KSHIFT=0	BLK	81
	NUMBLK=1	BLK	82
	NM=ND	BLK	83
	NL=1	BLK	84
	THETA=DELTA*PI/180.	BLK	85
	SLIP=TAN(THETA)	BLK	86
	SLIP=1.1*SLIP	BLK	87
50	WRITE (6,310) KSHIFT,NUMBLK,NM,NL,ND	BLK	88
	DO 290 KI=1,NELEMNT	BLK	89
	NT=IX(7,KI)	BLK	90
	MT=IX(8,KI)	BLK	91
	ENDRNL=KN	BLK	92
	ES=KS	BLK	93
	IF (NT.LE.2) GO TO 85	BLK	94
	IF (1.STOP.LE.9) GO TO 85	BLK	95
	IF (NT.NE.UNAT) GO TO 55	BLK	96
	GO TO 85	BLK	97
55	IMAT=MT	BLK	98
	CALL READHC (4,PROP,319,MT)	BLK	99
	ANISO=PROP(1)	BLK	100
	FRATIO=PROP(3)	BLK	101
	MO=3	BLK	102
	DO 60 I=1,7	BLK	103
	MO=MO+1	BLK	104
60	XP(I)=PROP(MO)	BLK	105
	DO 65 I=1,11	BLK	106
	DO 65 J=1,7	BLK	107
	MO=MO+1	BLK	108
65	EP(I,J)=PROP(MO)	BLK	109
	DO 70 I=1,11	BLK	110
	DO 70 J=1,7	BLK	111
	MO=MO+1	BLK	112

70	SEP(I,J)=PROP(MD)	BLK 113
	DO 75 I=1,11	BLK 114
	DO 75 J=1,7	BLK 115
	MD=MD+1	BLK 116
75	PSNR(I,J)=PROP(MD)	BLK 117
	DO 80 I=1,11	BLK 118
	DO 80 J=1,7	BLK 119
	MD=MD+1	BLK 120
80	SPSHR(I,J)=PROP(MD)	BLK 121
	NP=INT(PROD(319))	BLK 122
85	CONTINUE	BLK 123
C		BLK 124
C	SEARCH FOR ELEMENTS BELONG TO THIS LAYER	BLK 125
C		BLK 126
	GO TO (90,120,200,200,200), NT	BLK 127
C		BLK 128
C	TYPE I ELEMENTS	BLK 129
C		BLK 130
90	DO 95 I=1,2	BLK 131
95	LM(I)=3*IX(I,KI)-3	BLK 132
	DO 100 I=1,2	BLK 133
	IF (LM(I)+1,LT,NL) GO TO 100	BLK 134
	IF (LM(I)+1,LE,NM) GO TO 105	BLK 135
100	CONTINUE	BLK 136
	GO TO 290	BLK 137
105	I1=IX(1,KI)	BLK 138
	I2=IX(2,KI)	BLK 139
	CALL RING (KI,RADIUS,EI,YCEN,X(I1),X(I2),Y(I1),Y(I2),SR)	BLK 140
C		BLK 141
C	JOIN TYPE I ELEMENTS	BLK 142
C		BLK 143
	DO 115 I=1,2	BLK 144
	DO 115 K=1,3	BLK 145
	II=LM(I)+K-KSHIFT	BLK 146
	IF (II,LE,0,OR,II,GT,ND) GO TO 115	BLK 147
	KK=3*I-3+K	BLK 148
	DO 110 J=1,2	BLK 149
	DO 110 L=1,3	BLK 150
	JJ=LM(J)+L-KSHIFT-II+1	BLK 151
	IF (JJ,LE,0) GO TO 110	BLK 152
	LL=3*J-3+L	BLK 153
	A(JJ,II)=A(JJ,II)+SR(KK,LL)	BLK 154
110	CONTINUE	BLK 155
115	CONTINUE	BLK 156
	GO TO 290	BLK 157
C		BLK 158
C	TYPE II ELEMENTS	BLK 159
C		BLK 160
120	DO 125 I=1,2	BLK 161
	LM(I)=3*IX(I,KI)-3	BLK 162
125	CONTINUE	BLK 163
	DO 130 I=3,4	BLK 164
130	LM(I)=2*IX(I,KI)-2*NT3	BLK 165
	DO 135 I=1,4	BLK 166
	IF (LM(I)+1,LT,NL) GO TO 135	BLK 167
	IF (LM(I)+1,LE,NM) GO TO 140	BLK 168
135	CONTINUE	BLK 169
	GO TO 290	BLK 170
140	I1=IX(1,KI)	BLK 171
	I2=IX(2,KI)	BLK 172

	EN=ENDRML	BLK 173
	YC=0.5*(YC(I1)+YC(I2))	BLK 174
	CALL READMS (1,TEMP,17,KI)	BLK 175
	CALL READMS (1,TEMP,17,KI+1)	BLK 176
	IF (INTER.LE.0) GO TO 160	BLK 177
	IF (YC.GT.H2) GO TO 160	BLK 178
	IF (YC.GT.H1.AND.HCYCLE.EQ.1) GO TO 160	BLK 179
	SIGMA=(TEMP(1)+TEMP(1))/2.	BLK 180
	TAU=(TEMP(2)+TEMP(2))/2.	BLK 181
	IF (ABS(SIGMA).LT.GAMA(MT)) GO TO 160	BLK 182
	IF (SIGMA+GAMA(MT)) 155,145,145	BLK 183
145	RO=TAU/SIGMA	BLK 184
	RATIO=ABS(RO)	BLK 185
	IF (RATIO.GT.SLIP) GO TO 150	BLK 186
	GO TO 160	BLK 187
150	ES=1000.0	BLK 188
	WRITE (6,320) KI	BLK 189
	GO TO 165	BLK 190
155	ES=1000.0	BLK 191
	EN=ES	BLK 192
	WRITE (6,315) KI	BLK 193
	GO TO 165	BLK 194
	ES=100.0	BLK 195
	EN=ES	BLK 196
	GO TO 165	BLK 197
160	EN=ENDRML	BLK 198
165	CALL JOINT (KI,YCEN,EN,ES,X(I1),X(I2),Y(I1),Y(I2),TH1,TH2,SKJ) BLK 199	
	IX(5,KI)=INT(TH1)	BLK 200
	IX(6,KI)=INT(TH2)	BLK 201
	TEMP(3)=EN	BLK 202
	TEMP(4)=ES	BLK 203
	CALL WRITMS (1,TEMP,17,KI)	BLK 204
C		BLK 205
C	JOIN TYPE II ELEMENT	BLK 206
C		BLK 207
	DO 175 I=1,4	BLK 208
	DO 175 K=1,2	BLK 209
	II=LM(I)+K-KSHIFT	BLK 210
	IF (II.LE.0.OR.II.GT.ND) GO TO 175	BLK 211
	KK=2*I-2*K	BLK 212
	DO 170 J=1,4	BLK 213
	DO 170 L=1,2	BLK 214
	JJ=LM(J)+L-KSHIFT-II+1	BLK 215
	LL=2*J-2*L	BLK 216
	IF (JJ.LE.0) GO TO 170	BLK 217
	A(JJ,II)=A(JJ,II)+SKJ(KK,LL)	BLK 218
170	CONTINUE	BLK 219
175	CONTINUE	BLK 220
C		BLK 221
	DO 180 I=1,2	BLK 222
180	LM(I)=3*IX(I,KI+1)-3	BLK 223
	DO 185 I=3,4	BLK 224
185	LM(I)=2*IX(I,KI+1)-2+M(I)	BLK 225
	I1=IX(1,KI+1)	BLK 226
	I2=IX(2,KI+1)	BLK 227
	CALL JOINT (KI+1,YCEN,EN,ES,X(I1),X(I2),Y(I1),Y(I2),TH1,TH2,SKJ) BLK 228	
1	T)	BLK 229
	IX(5,KI+1)=INT(TH1)	BLK 230
	IX(6,KI+1)=INT(TH2)	BLK 231
	TEMP(3)=EN	BLK 232

	TEMP(4)=ES	BLK 233
	CALL WRITMS (1,TEMP,17,KI+1)	BLK 234
	DO 195 I=1,4	BLK 235
	DO 195 K=1,2	BLK 236
	II=LM(I)+K-KSHIFT	BLK 237
	IF (II.LE.0.OR.II.GT.ND) GO TO 195	BLK 238
	KK=2*I-2+K	BLK 239
	DO 190 J=1,4	BLK 240
	DO 190 L=1,2	BLK 241
	JJ=LM(J)+L-KSHIFT-II+1	BLK 242
	LL=2*J-2+L	BLK 243
	IF (JJ.LE.0) GO TO 190	BLK 244
	A(JJ,II)=A(JJ,II)+SKJT(KK,LL)	BLK 245
190	CONTINUE	BLK 246
195	CONTINUE	BLK 247
	KI=KI+1	BLK 248
C		BLK 249
	GO TO 290	BLK 250
C		BLK 251
C		BLK 252
C	TRIANGULAR ELEMENT TYPE III	BLK 253
200	MK=NT-2	BLK 254
	GO TO (205,215,220), MK	BLK 255
205	DO 210 I=1,6	BLK 256
210	LM(I)=2*IX(1,KI)-2+NT3	BLK 257
	GO TO 230	BLK 258
215	LM(1)=3*IX(1,KI)-3	BLK 259
	LM(2)=3*IX(2,KI)-3	BLK 260
	LM(3)=2*IX(3,KI)-2+NT3	BLK 261
	LM(4)=3*IX(4,KI)-3	BLK 262
	LM(5)=2*IX(5,KI)-2+NT3	BLK 263
	LM(6)=2*IX(6,KI)-2+NT3	BLK 264
	GO TO 230	BLK 265
220	DO 225 I=1,6	BLK 266
225	LM(I)=2*IX(1,KI)-2+NT3	BLK 267
	LM(3)=3*IX(3,KI)-3	BLK 268
230	DO 235 I=1,6	BLK 269
	IF (LM(I)+1.LT.NL) GO TO 235	BLK 270
	IF (LM(I)+1.LE.NM) GO TO 240	BLK 271
235	CONTINUE	BLK 272
	GO TO 290	BLK 273
240	I1=IX(1,KI)	BLK 274
	I2=IX(2,KI)	BLK 275
	I3=IX(3,KI)	BLK 276
	YC=(Y(I1)+Y(I2)+Y(I3))/3.	BLK 277
C		BLK 278
C		BLK 279
C	TYPE III ELEMENT	BLK 280
	IF (ISTOP.LE.0) GO TO 270	BLK 281
	IF (YC.GT.H2) GO TO 265	BLK 282
	IF (YC.GT.H1.AND.NCYCLE.EQ.1) GO TO 270	BLK 283
	CALL READMS (1,TEMP,17,KI)	BLK 284
	STRESSX=ABS(TEMP(7))	BLK 285
	TAUOCT=ABS(TEMP(8))	BLK 286
	TAUF=STRESSX*FRATIO	BLK 287
	RATIO=TAUOCT/TAUF	BLK 288
	IF (RATIO.GT.1.0) WRITE (6,325) RATIO,KI	BLK 289
245	LI=1,10	BLK 290
	R1=FLOAT(LI-1)/10.	BLK 291
	R2=FLOAT(LI)/10.	BLK 292

	LJ=LI-LI+1	BLK	293
	IF (RATIO.GT.R1.AND.RATIO.LE.R2) GO TO 250	BLK	294
245	CONTINUE	BLK	295
	LJ=2	BLK	296
C		BLK	297
C	* LJ * IS THE ET VS. SIGMA3 CURVE NO. SELECTED BASED ON STRESS RATE	BLK	298
C	NOW SELECT INTERVAL OF CONFINING PRESSURE	BLK	299
C		BLK	300
250	IF (STRESSX.LT.XP(L).OR.STRESSX.GT.XP(LP)) WRITE (6,330) STRESS	BLK	301
1	X,KI	BLK	302
	DO 255 LK=2,NP	BLK	303
	LI=LK	BLK	304
	IF (STRESSX.GE.XP(LK-1).AND.STRESSX.LE.XP(LK)) GO TO 260	BLK	305
255	CONTINUE	BLK	306
	LI=NP	BLK	307
260	YDP1=SEP(LJ,LI-1)	BLK	308
	YDPH1=SPSHR(LJ,LI-1)	BLK	309
	YDP2=SEP(LJ,LI)	BLK	310
	YDPH2=SPSHR(LJ,LI)	BLK	311
	X1=XP(LI-1)	BLK	312
	X2=XP(LI)	BLK	313
	Y1=EP(LJ,LI-1)	BLK	314
	YN1=PSNR(LJ,LI-1)	BLK	315
	Y2=EP(LJ,LI)	BLK	316
	YN2=PSNR(LJ,LI)	BLK	317
	PP=STRESSX	BLK	318
	ET1=ORDINET(YDP1,YDP2,X1,X2,Y1,Y2,PP)	BLK	319
	PSH1=ORDINET(YDPH1,YDPH2,X1,X2,YN1,YN2,PP)	BLK	320
	YDP1=SEP(LJ-1,LI-1)	BLK	321
	YDPH1=SPSHR(LJ-1,LI-1)	BLK	322
	YDP2=SEP(LJ-1,LI)	BLK	323
	YDPH2=SPSHR(LJ-1,LI)	BLK	324
	Y1=EP(LJ-1,LI-1)	BLK	325
	YN1=PSNR(LJ-1,LI-1)	BLK	326
	Y2=EP(LJ-1,LI)	BLK	327
	YN2=PSNR(LJ-1,LI)	BLK	328
	ET2=ORDINET(YDP1,YDP2,X1,X2,Y1,Y2,PP)	BLK	329
	PSH2=ORDINET(YDPH1,YDPH2,X1,X2,YN1,YN2,PP)	BLK	330
	EY=ET2+(ET1-ET2)*(RATIO-R1)	BLK	331
	NUEY=PSH2+(PSH1-PSH2)*(RATIO-R1)	BLK	332
	EX=ANISO*EY	BLK	333
	NUEX=NUEY*EX/EY	BLK	334
	GO TO 275	BLK	335
265	EY=E(MT)/1000.0	BLK	336
	EX=ANISO*EY	BLK	337
	NUEY=NUE(MT)	BLK	338
	NUEX=NUEY*EX/EY	BLK	339
	GO TO 275	BLK	340
270	EY=E(MT)	BLK	341
	EX=ANISO*EY	BLK	342
	NUEY=NUE(MT)	BLK	343
	NUEX=NUEY*EX/EY	BLK	344
275	CALL TRANGLE (KI,NT,EX,EY,NUEX,NUEY,SK)	BLK	345
	DO 285 I=1,6	BLK	346
	DO 285 K=1,2	BLK	347
	II=LM(I)+K-KSHIFT	BLK	348
	IF (II.LE.0.OR.II.GT.ND) GO TO 285	BLK	349
	KK=I+(K-1)*6	BLK	350
	DO 280 J=1,6	BLK	351
	DO 280 L=1,2	BLK	352


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      JJ=LMCJ)+NL-KSHIFT+1-II          BLK 353
      IF (JJ.LE.0) GO TO 280           BLK 354
      LL=JJ+CL-1)*6                   BLK 355
      A(JJ,II)=A(JJ,II)+SK(KK,LL)     BLK 356
280      CONTINUE                     BLK 357
285      CONTINUE                     BLK 358
290      CONTINUE                     BLK 359
C                                     BLK 360
C                                     BLK 361
C                                     BLK 362
C                                     BLK 363
C                                     BLK 364
C                                     BLK 365
      CALL ZERO (ARRAY,NSIZE)          BLK 366
      NX=NL-1                          BLK 367
      DO 300 M=1,NSIZE                 BLK 368
      DO 295 N=1,NSIZE                 BLK 369
295      ARRAY(N)=A(M,N)               BLK 370
      CALL WRITMS (10,ARRAY,NSIZE,NX,M) BLK 371
300      CONTINUE                     BLK 372
      IF (NM.GE.NDOF) GO TO 305        BLK 373
      CALL NULLMAT (A,NSIZE,NSIZE)    BLK 374
      KSHIFT=KSHIFT+ND                BLK 375
      IF (NUMBLK.EQ.1) ND=ND+NDINC     BLK 376
      NUMBLK=NUMBLK+1                 BLK 377
      NM=NM+ND                        BLK 378
      NL=NM-ND+1                      BLK 379
      GO TO 50                         BLK 380
305      IF (NT3.GT.0) ND=ND+NDINC     BLK 381
      RETURN                           BLK 382
C                                     BLK 383
310      FORMAT (5X, 9HKSHIFT = ,I8,5X, 9HNUMBLK = ,I5, 8H NM = ,I5, BLK 384
      18H NL = ,I5, 7H ND = ,I5)      BLK 385
315      FORMAT (5X, 24HINTERACTION ELEMENT NO. ,I5,3X, 21HHAS FAILED IN TEBLK 386
      1NSION)                          BLK 387
320      FORMAT (5X, 26HINTERACTION ELEMENT NO. = ,I5,3X, 31H HAS FAILED INBLK 388
      1 EXCESSIVE SHEAR)               BLK 389
325      FORMAT (10X, 41HSTRESS RATIO IS GREATER THAN 1 , RATIO = ,F6.2,5X,BLK 390
      1 17HIN ELEMENT NO. = ,I5)      BLK 391
330      FORMAT (10X, 56HCONFINING PRESSURE IS OUT OF RANGE OF SIGMA3, STREBLK 392
      1SSK = ,E12.2,5X, 17HIN ELEMENT NO. = ,I5) BLK 393
C                                     BLK 394
      END                              TRG 2
      SUBROUTINE TRANGLE (K,NT,CX,EY,NUEX,NUEY,SK) TRG 3
      COMMON NNODES,NELEMNT,NDOF,MBAND,ND,NT3,ISTOP,NCYCLE,LAYERS,ISTEP,TRG 4
      1NSTEP,NT12,ETA,NT1,NT2,NDIMENS,IFLAG,NSIZE,NCODE(550),X(550),Y(550)TRG 5
      2),JNDX(51),ANLIS,IX(8,250),AREAA(250),INDX(250),INDEX(250),GAMA(2)TRG 6
      35),ZAI(3)                        TRG 7
      COMMON /1/ E,NUC,RADIUS,XJEN,YCEN,EI,KN,KS,H1,H2,INTER TRG 8
      COMMON /2/ D                      TRG 9
      DATA PLSTRS,PLSTRN/6HPLSTR/6HPLSTRN/ TRG 10
      REAL NUEX,NUEY,NUENS              TRG 11
      DIMENSION SK(12,12), E(10), NUC(10), D(10,10) TRG 12
      DIMENSION DD(3,3), DMAT(90)      TRG 13
      REAL KH,KS                        TRG 14
C                                     TRG 15
C                                     TRG 16
C                                     TRG 17
C                                     TRG 18
C                                     TRG 19
      *****
      GENERATE STIFFNESS MATRIX FOR TRIANGULAR ELEMENTS
      AA=AREAA(K)
      NT=IX(8,K)

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	TA=1./AA	TRG	20
C		TRG	21
C	TYPE III ELEMENT	TRG	22
C		TRG	23
	L=IX(1,K)	TRG	24
	M=IX(2,K)	TRG	25
	N=IX(3,K)	TRG	26
	X21=X(M)-X(L)	TRG	27
	X13=X(L)-X(N)	TRG	28
	X32=X(N)-X(M)	TRG	29
	Y12=Y(L)-Y(M)	TRG	30
	Y23=Y(M)-Y(N)	TRG	31
	Y31=Y(N)-Y(L)	TRG	32
	IF (ISTOP.LE.0) GO TO 5	TRG	33
	GO TO 10	TRG	34
5	D11=D(MT,1)	TRG	35
	D12=D(MT,2)	TRG	36
	D13=D(MT,3)	TRG	37
	D21=D(MT,4)	TRG	38
	D22=D(MT,5)	TRG	39
	D23=D(MT,6)	TRG	40
	D31=D(MT,7)	TRG	41
	D32=D(MT,8)	TRG	42
	D33=D(MT,9)	TRG	43
	GO TO 15	TRG	44
C		TRG	45
10	IF (ANLIS,EO,PLSTRS) CALL PLNSTRS (EX,EY,NUEX,NUFY,DD)	TRG	46
	IF (ANLIS,EO,PLSTRN) CALL VALUES (EX,EY,NUEX,NUFY,DD)	TRG	47
	D11=DD(1,1)	TRG	48
	D12=DD(1,2)	TRG	49
	D13=DD(1,3)	TRG	50
	D21=DD(2,1)	TRG	51
	D22=DD(2,2)	TRG	52
	D23=DD(2,3)	TRG	53
	D31=DD(3,1)	TRG	54
	D32=DD(3,2)	TRG	55
	D33=DD(3,3)	TRG	56
15	A1=D11*Y23+D13*X32	TRG	57
	A2=D31*Y23+D33*X32	TRG	58
	A3=D11*Y31+D13*X13	TRG	59
	A4=D31*Y31+D33*X13	TRG	60
	A5=D11*Y12+D13*X21	TRG	61
	A6=D31*Y12+D33*X21	TRG	62
	A7=D12*X32+D13*Y23	TRG	63
	A8=D32*X32+D33*Y23	TRG	64
	A9=D12*X13+D13*Y31	TRG	65
	A10=D32*X13+D33*Y31	TRG	66
	A11=D12*X21+D13*Y12	TRG	67
	A12=D32*X21+D33*Y12	TRG	68
C		TRG	69
	B1=D21*Y23+D23*X32	TRG	70
	B2=D21*Y31+D23*X13	TRG	71
	B3=D21*Y12+D23*X21	TRG	72
	B4=D22*X32+D23*Y23	TRG	73
	B5=D22*X13+D23*Y31	TRG	74
	B6=D22*X21+D23*Y12	TRG	75
C		TRG	76
	C11=Y23*A1+X32*A2	TRG	77
	C12=Y23*A3+X32*A4	TRG	78
	C13=Y23*A5+X32*A6	TRG	79

	C14=Y23*A7+X32*A8	TRG	80
	C15=Y23*A9+X32*A10	TRG	81
	C16=Y23*A11+X32*A12	TRG	82
C		TRG	83
	C21=Y31*A1+X13*A2	TRG	84
	C22=Y31*A3+X13*A4	TRG	85
	C23=Y31*A5+X13*A6	TRG	86
	C24=Y31*A7+X13*A8	TRG	87
	C25=Y31*A9+X13*A10	TRG	88
	C26=Y31*A11+X13*A12	TRG	89
C		TRG	90
	C31=Y12*A1+X21*A2	TRG	91
	C32=Y12*A3+X21*A4	TRG	92
	C33=Y12*A5+X21*A6	TRG	93
	C34=Y12*A7+X21*A8	TRG	94
	C35=Y12*A9+X21*A10	TRG	95
	C36=Y12*A11+X21*A12	TRG	96
C		TRG	97
	C41=X32*B1+Y23*A2	TRG	98
	C42=X32*B2+Y23*A4	TRG	99
	C43=X32*B3+Y23*A6	TRG	100
	C44=X32*B4+Y23*A8	TRG	101
	C45=X32*B5+Y23*A10	TRG	102
	C46=X32*B6+Y23*A12	TRG	103
C		TRG	104
	C51=X13*B1+Y31*A2	TRG	105
	C52=X13*B2+Y31*A4	TRG	106
	C53=X13*B3+Y31*A6	TRG	107
	C54=X13*B4+Y31*A8	TRG	108
	C55=X13*B5+Y31*A10	TRG	109
	C56=X13*B6+Y31*A12	TRG	110
C		TRG	111
	C63=X21*B3+Y12*A6	TRG	112
	C61=X21*B1+Y12*A2	TRG	113
	C62=X21*B2+Y12*A4	TRG	114
	C64=X21*B4+Y12*A8	TRG	115
	C65=X21*B5+Y12*A10	TRG	116
	C66=X21*B6+Y12*A12	TRG	117
C		TRG	118
	IF (K.GT.NT12.AND.K.LE.(NT12+NT1/2)) GO TO 20	TRG	119
	GO TO 25	TRG	120
20	ETTA=ETA/2.	TRG	121
	ETATWO=1.-2.*ETTA	TRG	122
	ETAFOUR=1.-4.*ETTA	TRG	123
	ETA2=ETATWO*ETATWO	TRG	124
	ETA4=ETAFOUR*ETAFOUR	TRG	125
	GO TO 30	TRG	126
25	ETTA=0.0	TRG	127
	ETAFOUR=1.0	TRG	128
	ETATWO=ETAFOUR	TRG	129
	ETA4=1.0	TRG	130
	ETA2=ETA4	TRG	131
C		TRG	132
C		TRG	133
30	SK(1,1)=C11*TA*(1.+4.*ETTA/3.+4.*ETTA*ETTA)/(ETATWO*ETATWO*4.)	TRG	134
	SK(2,1)=-C12*TA/(12.*ETAFOUR)	TRG	135
	SK(1,2)=SK(2,1)	TRG	136
C		TRG	137
	SK(1,3)=C13*TA*(-0.333+2.*ETTA+8.*ETTA*ETTA)/(4.*ETATWO)	TRG	138
	SK(3,1)=SK(1,3)	TRG	139

	$SK(2,3)=-C23*TA/12,$	TRG	140
	$SK(3,2)=SK(2,3)$	TRG	141
	$SK(2,2)=C22*TA/(4,*ETA4)$	TRG	142
	$SK(3,3)=C33*TA*(1,+8,*ETTA/3,+16,*ETTA*ETTA)/4,$	TRG	143
C		TRG	144
	$SK(1,4)=TA*(C11*2,*ETTA+C12*(4./3.+8,*ETTA/3.))/(4,*ETA2*ETATHD)$	TRG	145
	$SK(4,1)=SK(1,4)$	TRG	146
	$SK(2,4)=C21*TA/(3,*ETA2*ETAFDUR)$	TRG	147
	$SK(4,2)=SK(2,4)$	TRG	148
	$SK(3,4)=4,*(C31+C32)*TA*ETTA/(3,*ETA2)$	TRG	149
	$SK(4,3)=SK(3,4)$	TRG	150
	$SK(4,4)=(2,*C11+C12+C21+2,*C22)*TA/(3,*ETA2*ETA2)$	TRG	151
C		TRG	152
	$SK(1,5)=2,*ETTA*(C11+C13)*TA/(3,*ETATHD*ETAFDUR)$	TRG	153
	$SK(5,1)=SK(1,5)$	TRG	154
	$SK(2,5)=C23*TA/(3,*ETA4)$	TRG	155
	$SK(5,2)=SK(2,5)$	TRG	156
	$SK(3,5)=(C32*(1,+4,*ETTA)+C33*4,*ETTA)*TA/(3,*ETAFDUR)$	TRG	157
	$SK(5,3)=SK(3,5)$	TRG	158
	$SK(4,5)=TA*(C12+2,*C13+C22+C23)/(3,*ETAFDUR*ETA2)$	TRG	159
	$SK(5,4)=SK(4,5)$	TRG	160
	$SK(5,5)=TA*(2,*C22+C23+C32+2,*C33)/(3,*ETA4)$	TRG	161
C		TRG	162
	$SK(1,6)=TA*(C13+2,*ETTA*(C11+C13))/(3,*ETATHD*ETAFDUR)$	TRG	163
	$SK(6,1)=SK(1,6)$	TRG	164
	$SK(2,6)=0,0$	TRG	165
	$SK(6,2)=SK(2,6)$	TRG	166
	$SK(3,6)=TA*(C31+4,*ETTA*(C31+C33))/(3,*ETAFDUR)$	TRG	167
	$SK(6,3)=SK(3,6)$	TRG	168
	$SK(4,6)=TA*(C11+C13+C21+2,*C23)/(3,*ETAFDUR*ETA2)$	TRG	169
	$SK(6,4)=SK(4,6)$	TRG	170
	$SK(5,6)=TA*(2,*C21+C23+C31+C33)/(3,*ETA4)$	TRG	171
	$SK(6,5)=SK(5,6)$	TRG	172
	$SK(6,6)=TA*(2,*C11+C13+C31+2,*C33)/(3,*ETA4)$	TRG	173
C		TRG	174
	$SK(1,7)=C14*TA*(1,+4,*ETTA/3,+4,*ETTA*ETTA)/(4,*ETA2)$	TRG	175
	$SK(7,1)=SK(1,7)$	TRG	176
	$SK(2,7)=-C24*TA/(12,*ETAFDUR)$	TRG	177
	$SK(7,2)=SK(2,7)$	TRG	178
	$SK(3,7)=-C34*TA*(1,-6,*ETTA-24,*ETTA*ETTA)/(12,*ETATHD)$	TRG	179
	$SK(7,3)=SK(3,7)$	TRG	180
	$SK(4,7)=TA*(2,*C14*ETTA+C24*(1,+2,*ETTA))/(3,*ETA2*ETATHD)$	TRG	181
	$SK(7,4)=SK(4,7)$	TRG	182
	$SK(5,7)=2,*ETTA*TA*(C24+C34)/(3,*ETATHD*(1,+2,*ETTA))$	TRG	183
	$SK(7,5)=SK(5,7)$	TRG	184
	$SK(6,7)=TA*(2,*C14*ETTA+C34*(1,+2,*ETTA))/(3,*ETATHD*ETAFDUR)$	TRG	185
	$SK(7,6)=SK(6,7)$	TRG	186
	$SK(7,7)=TA*(C44*(1,+4,*ETTA/3,+4,*ETTA*ETTA)/(4,*ETA2)$	TRG	187
C		TRG	188
	$SK(1,8)=TA*(C15*(-1,+2,*ETTA))/(12,*ETAFDUR*ETATHD)$	TRG	189
	$SK(8,1)=SK(1,8)$	TRG	190
	$SK(2,8)=TA*(C25/(4,*ETA4)$	TRG	191
	$SK(8,2)=SK(2,8)$	TRG	192
	$SK(3,8)=-C35*TA/12,$	TRG	193
	$SK(8,3)=SK(3,8)$	TRG	194
	$SK(4,8)=C15*TA/(3,*ETAFDUR*ETA2)$	TRG	195
	$SK(8,4)=SK(4,8)$	TRG	196
	$SK(5,8)=C35*TA/(3,*ETA4)$	TRG	197
	$SK(8,5)=SK(5,8)$	TRG	198
	$SK(6,8)=0,0$	TRG	199

	$SK(8,6)=SK(6,8)$	TRG	200
	$SK(7,8)=-C45*TA/(12,*ETAFDUR)$	TRG	201
	$SK(8,7)=SK(7,8)$	TRG	202
	$SK(8,8)=C55*TA/(4,*ETA4)$	TRG	203
C		TRG	204
	$SK(1,9)=-C16*TA*(1,-2,*ETTA-8,*ETTA*ETTA)/(12,*ETATWD)$	TRG	205
	$SK(9,1)=SK(1,9)$	TRG	206
	$SK(2,9)=-C26*TA/12,$	TRG	207
	$SK(9,2)=SK(2,9)$	TRG	208
	$SK(3,9)=C36*TA*(1,+8,*ETTA/3,+16,*ETTA*ETTA)/4,$	TRG	209
	$SK(9,3)=SK(3,9)$	TRG	210
	$SK(4,9)=4,*ETTA*TA*(C16+C26)/(3,*ETA2)$	TRG	211
	$SK(9,4)=SK(4,9)$	TRG	212
	$SK(5,9)=TA*(C26*(1,+4,*ETTA)+C36*4,*ETTA)/(3,*ETAFDUR)$	TRG	213
	$SK(9,5)=SK(5,9)$	TRG	214
	$SK(6,9)=TA*(C16*(1,+4,*ETTA)+C36*4,*ETTA)/(3,*ETAFDUR)$	TRG	215
	$SK(9,6)=SK(6,9)$	TRG	216
	$SK(7,9)=-TA*C46*(1,-6,*ETTA-24,*ETTA*ETTA)/(12,*ETATWD)$	TRG	217
	$SK(9,7)=SK(7,9)$	TRG	218
	$SK(8,9)=-C56*TA/12,$	TRG	219
	$SK(9,8)=SK(8,9)$	TRG	220
	$SK(9,9)=C66*TA*(1,+8,*ETTA/3,+16,*ETTA*ETTA)/4,$	TRG	221
C		TRG	222
	$SK(1,10)=TA*(C14*2,*ETTA+C15*(1,+2,*ETTA))/(3,*ETATWD*ETA2)$	TRG	223
	$SK(10,1)=SK(1,10)$	TRG	224
	$SK(2,10)=C24*TA/(3,*ETAFDUR*ETA2)$	TRG	225
	$SK(10,2)=SK(2,10)$	TRG	226
	$SK(3,10)=4,*TA*ETTA*(C34+C35)/(3,*ETA2)$	TRG	227
	$SK(10,3)=SK(3,10)$	TRG	228
	$SK(4,10)=TA*(2,*C14+C15+C24+2,*C25)/(3,*ETA2*ETA2)$	TRG	229
	$SK(10,4)=SK(4,10)$	TRG	230
	$SK(5,10)=TA*(C24+C25+2,*C34+C35)/(3,*ETAFDUR*ETA2)$	TRG	231
	$SK(10,5)=SK(5,10)$	TRG	232
	$SK(6,10)=TA*(C14+C15+C34+2,*C35)/(3,*ETA2*ETAFDUR)$	TRG	233
	$SK(10,6)=SK(6,10)$	TRG	234
	$SK(7,10)=TA*(2,*ETTA*C44+C45*(1,+2,*ETTA))/(3,*ETA2*ETATWD)$	TRG	235
	$SK(10,7)=SK(7,10)$	TRG	236
	$SK(8,10)=C54*TA/(3,*ETAFDUR*ETA2)$	TRG	237
	$SK(10,8)=SK(8,10)$	TRG	238
	$SK(9,10)=4,*ETTA*TA*(C64+C65)/(3,*ETA2)$	TRG	239
	$SK(10,9)=SK(9,10)$	TRG	240
	$SK(10,10)=TA*(2,*C44+C45+C54+2,*C55)/(3,*ETA4*ETA4)$	TRG	241
C		TRG	242
	$SK(1,11)=2,*ETTA*TA*(C15+C16)/(3,*ETATWD*ETAFDUR)$	TRG	243
	$SK(11,1)=SK(1,11)$	TRG	244
	$SK(2,11)=C26*TA/(3,*ETA4)$	TRG	245
	$SK(11,2)=SK(2,11)$	TRG	246
	$SK(3,11)=TA*(C35*(1,+4,*ETTA)+4,*ETTA*C36)/(3,*ETAFDUR)$	TRG	247
	$SK(11,3)=SK(3,11)$	TRG	248
	$SK(4,11)=TA*(C15+2,*C16+C25+C26)/(3,*ETAFDUR*ETA2)$	TRG	249
	$SK(11,4)=SK(4,11)$	TRG	250
	$SK(5,11)=TA*(2,*C25+C26+C35+2,*C36)/(3,*ETA4)$	TRG	251
	$SK(11,5)=SK(5,11)$	TRG	252
	$SK(6,11)=TA*(2,*C15+C16+C35+C36)/(3,*ETA4)$	TRG	253
	$SK(11,6)=SK(6,11)$	TRG	254
	$SK(7,11)=TA*2,*ETTA*(C45+C46)/(3,*ETATWD*ETAFDUR)$	TRG	255
	$SK(11,7)=SK(7,11)$	TRG	256
	$SK(8,11)=TA*C56/(3,*ETA4)$	TRG	257
	$SK(11,8)=SK(8,11)$	TRG	258
	$SK(9,11)=TA*(C65*(1,+4,*ETTA)+4,*ETTA*C66)/(3,*ETAFDUR)$	TRG	259

	SK(11,9)=SK(9,11)	TRG	260
	SK(10,11)=TA*(C45+2.*C46+C55+C56)/(3.*ETAFOUR*ETA2)	TRG	261
	SK(11,10)=SK(10,11)	TRG	262
	SK(11,11)=TA*(2.*C55+C56+C65+2.*C66)/(3.*ETA4)	TRG	263
C		TRG	264
	SK(1,12)=TA*(C14*2.*ETTA+C16*(1.+2.*ETTA))/(3.*ETATWO)	TRG	265
	SK(12,1)=SK(1,12)	TRG	266
	SK(2,12)=0,0	TRG	267
	SK(12,2)=SK(2,12)	TRG	268
	SK(3,12)=TA*(C34*(1.+4.*ETTA)+C36*4.*ETTA)/(3.*ETAFOUR)	TRG	269
	SK(12,3)=SK(3,12)	TRG	270
	SK(4,12)=TA*(C14+C16+C24+2.*C26)/(3.*ETAFOUR*ETA2)	TRG	271
	SK(12,4)=SK(4,12)	TRG	272
	SK(5,12)=TA*(2.*C24+C26+C34+C36)/(3.*ETA4)	TRG	273
	SK(12,5)=SK(5,12)	TRG	274
	SK(6,12)=TA*(2.*C14+C16+C34+2.*C36)/(3.*ETA4)	TRG	275
	SK(12,6)=SK(6,12)	TRG	276
	SK(7,12)=TA*(2.*ETTA*C44+(1.+2.*ETTA)*C46)/(3.*ETATWO*ETAFOUR)	TRG	277
	SK(12,7)=SK(7,12)	TRG	278
	SK(8,12)=0,0	TRG	279
	SK(12,8)=SK(8,12)	TRG	280
	SK(9,12)=TA*(C64*(1.+4.*ETTA)+C66*4.*ETTA)/(3.*ETAFOUR)	TRG	281
	SK(12,9)=SK(9,12)	TRG	282
	SK(10,12)=TA*(C44+C46+C54+2.*C56)/(3.*ETAFOUR*ETA2)	TRG	283
	SK(12,10)=SK(10,12)	TRG	284
	SK(11,12)=TA*(2.*C54+C56+C64+C66)/(3.*ETA4)	TRG	285
	SK(12,11)=SK(11,12)	TRG	286
	SK(12,12)=TA*(2.*C44+C46+C64+2.*C66)/(3.*ETA4)	TRG	287
C		TRG	288
C		TRG	289
	MD=0	TRG	290
	DO 45 I=1,3	TRG	291
	DO 45 J=1,3	TRG	292
	MD=MD+1	TRG	293
	IF (ISTOP) 35,35,40	TRG	294
35	DMAT(MD)=DMAT(MD)	TRG	295
	GO TO 45	TRG	296
40	DMAT(MD)=DD(I,J)	TRG	297
45	CONTINUE	TRG	298
	DMAT(10)=HUEX	TRG	299
	DMAT(11)=HUEY	TRG	300
	MD=11	TRG	301
	DO 55 I=1,12	TRG	302
	DO 50 J=1,12	TRG	303
	MD=MD+1	TRG	304
50	DMAT(MD)=SK(I,J)	TRG	305
55	CONTINUE	TRG	306
	CALL WRITMS (3,DMAT,89,K)	TRG	307
	RETURN	TRG	308
C		TRG	309
	END	TRG	310
	SUBROUTINE MATMULT (A,B,C,M,N)	MAT	2
	DIMENSION A(M,N), B(M,N), C(M,N)	MAT	3
C		MAT	4
C	MATRIX * A * IS MULTIPLIED WITH * B * AND STORED IN * C *	MAT	5
C		MAT	6
	DO 10 I=1,M	MAT	7
	DO 10 J=1,N	MAT	8
	SUM=0,0	MAT	9
	DO 5 K=1,M	MAT	10

5	SUM=SUM+A(I,K)*B(K,J)	MAT	11
10	C(I,J)=SUM	MAT	12
	RETURN	MAT	13
C		MAT	14
	ENTRY MATRIMUL	MAT	15
C		MAT	16
C	TRANSPOSE OF * A * IS MULTIPLIED WITH * B * AND STORED INTO * C *	MAT	17
C		MAT	18
	DO 20 I=1,M	MAT	19
	DO 20 J=1,N	MAT	20
	SUM=0.0	MAT	21
	DO 15 K=1,N	MAT	22
15	SUM=SUM+A(K,I)*B(K,J)	MAT	23
20	C(I,J)=SUM	MAT	24
	RETURN	MAT	25
C		MAT	26
	END	MAT	27
	SUBROUTINE VALUES (EX,EY,NUEX,HUEY,DD)	VLU	2
C		VLU	3
C	CALCULATE = DD = MATRIX FOR PLANE STRAIN SITUATION	VLU	4
C		VLU	5
	DIMENSION DD(3,3)	VLU	6
	REAL NUEX,HUEY	VLU	7
	RN=EX/EY	VLU	8
	RM=0.5/(1.+HUEY)	VLU	9
	C=EY/((1.+NUEX)*(1.-NUEX-2.*RN*HUEY*HUEY))	VLU	10
	DD(1,1)=C*RN*(1.-RN*HUEY*HUEY)	VLU	11
	DD(2,1)=C*RN*(1.+NUEX)*HUEY	VLU	12
	DD(1,2)=DD(2,1)	VLU	13
	DD(2,2)=C*(1.-NUEX*NUEX)	VLU	14
	DD(3,3)=C*RN*(1.+HUEX)*(1.-HUEX-2.*RN*HUEY*HUEY)	VLU	15
	DD(3,2)=0.0	VLU	16
	DD(3,1)=DD(3,2)	VLU	17
	DD(2,3)=DD(3,1)	VLU	18
	DD(1,3)=DD(2,3)	VLU	19
	RETURN	VLU	20
C		VLU	21
	END	VLU	22
	SUBROUTINE PLHSTRS (EX,EY,NUEX,HUEY,DD)	PLS	2
C		PLS	3
C	CALCULATE = DD = MATRIX FOR PLANE STRESS SITUATION	PLS	4
C		PLS	5
	DIMENSION DD(3,3)	PLS	6
	REAL NUEX,HUEY	PLS	7
	RN=EX/EY	PLS	8
	RM=0.5/(1.+HUEY)	PLS	9
	C=EY/(1.-RN*HUEY*HUEY)	PLS	10
	DD(1,1)=C*RN	PLS	11
	DD(2,1)=C*RN*HUEY	PLS	12
	DD(1,2)=DD(2,1)	PLS	13
	DD(2,2)=C	PLS	14
	DD(3,3)=C*RM*(1.-RN*HUEY*HUEY)	PLS	15
	DD(3,2)=0.0	PLS	16
	DD(3,1)=DD(3,2)	PLS	17
	DD(2,3)=DD(3,1)	PLS	18
	DD(1,3)=DD(2,3)	PLS	19
	RETURN	PLS	20
C		PLS	21
	END	PLS	22
	FUNCTION ORDINET(A,B,C,D,E,F,P)	ORD	2

C		ORD	3
C	DETERMINE TANGENT MODULUS USING SPLINE FUNCTION	ORD	4
C		ORD	5
	HJ=D-C	ORD	6
	B1=D-P	ORD	7
	B2=P-C	ORD	8
	A1=B1*B1*B1	ORD	9
	A2=B2*B2*B2	ORD	10
	T1=A1*A/(6.*HJ)	ORD	11
	T2=A2*B/(6.*HJ)	ORD	12
	T3=(E-A*HJ*HJ/6.)*(D-P)/HJ	ORD	13
	T4=(F-B*HJ*HJ/6.)*(P-C)/HJ	ORD	14
	ORDINET=T1+T2+T3+T4	ORD	15
	RETURN	ORD	16
C		ORD	17
	END	ORD	18
	SUBROUTINE RING (KI,R,EI,YCEN,X1,X2,Y1,Y2,SK)	RNG	2
	DIMENSION SR(6,6), SK(6,6)	RNG	3
	DIMENSION TL(6,6), TC(6,6)	RNG	4
	DIMENSION TMP(36)	RNG	5
	REAL NUE	RNG	6
C		RNG	7
C	STIFFNESS MATRIX FOR RING ELEMENTS	RNG	8
C		RNG	9
	SPAN=SQRT((X1-X2)**2+(Y1-Y2)**2)	RNG	10
	BETA=SPAN/R	RNG	11
	BETA2=2.*BETA	RNG	12
	SH=SIN(BETA)	RNG	13
	CS=COS(BETA)	RNG	14
	SH2=SIN(BETA2)	RNG	15
	A=BETA-SH	RNG	16
	B=CS+SH*SH/2.-1.	RNG	17
	C=1.5*BETA-2.*SH+SH2/4.	RNG	18
	D=0.5*BETA-SH2/4.	RNG	19
	E=CS-1.	RNG	20
	AA=E*E/BETA-D	RNG	21
	BB=B-A*E/BETA	RNG	22
	CC=A*D-B*E	RNG	23
	DD=A*A/BETA-C	RNG	24
	EE=C*E-A*B	RNG	25
	FF=B*B-C*D	RNG	26
	G=B*(B-2.*A*E/BETA)+C*(E*E/BETA-D)+A*A*B/BETA	RNG	27
	FT=E1/(R**3)*G	RNG	28
	SR(1,1)=FT*AA	RNG	29
	SR(1,2)=FT*BB	RNG	30
	SR(2,1)=SR(1,2)	RNG	31
	SR(1,3)=FT*CC*R/BETA	RNG	32
	SR(3,1)=SR(1,3)	RNG	33
	SR(2,2)=FT*DD	RNG	34
	SR(2,3)=FT*EE*R/BETA	RNG	35
	SR(3,2)=SR(2,3)	RNG	36
	SR(3,3)=FT*FF*R/BETA	RNG	37
	SR(4,1)=-FT*(AA*CS+BB*SN)	RNG	38
	SR(1,4)=SR(4,1)	RNG	39
	SR(4,2)=-FT*(BB*CS+DD*SN)	RNG	40
	SR(2,4)=SR(4,2)	RNG	41
	SR(4,3)=-FT*(CC*CS+EE*SN)*R/BETA	RNG	42
	SR(3,4)=SR(4,3)	RNG	43
	SR(1,5)=FT*(AA*SN-BB*CS)	RNG	44
	SR(5,1)=SR(1,5)	RNG	45

SR(5,2)=FT*(BB*SH-DD*CS)	RNG	46	
SR(2,5)=SR(5,2)	RNG	47	
SR(5,3)=FT*(CC*SH-EE*CS)*R/BETA	RNG	48	
SR(3,5)=SR(5,3)	RNG	49	
SR(6,1)=FT*(AA*(CS-1.))+BL*SH-CC/BETA)*R	RNG	50	
SR(1,6)=SR(6,1)	RNG	51	
SR(6,2)=FT*(BB*(CS-1.))+DI*SH-EE/BETA)*R	RNG	52	
SR(2,6)=SR(6,2)	RNG	53	
SR(6,3)=FT*(CC*(CS-1.))+EL*SH-FF/BETA)*R	RNG	54	
SR(3,6)=SR(6,3)	RNG	55	
SR(4,4)=SR(1,1)	RNG	56	
SR(4,5)=-SR(1,2)	RNG	57	
SR(5,4)=SR(4,5)	RNG	58	
SR(4,6)=SR(1,3)	RNG	59	
SR(6,4)=SR(4,6)	RNG	60	
SR(5,5)=SR(2,2)	RNG	61	
SR(5,6)=-SR(2,3)	RNG	62	
SR(6,5)=SR(5,6)	RNG	63	
SR(6,6)=SR(3,3)	RNG	64	
C	RNG	65	
C	TRANSFORMATION OF COORDINATE SYSTEM	RNG	66
C		RNG	67
CALL NULLMAT (TL,6,6)	RNG	68	
CALL NULLMAT (TC,6,6)	RNG	69	
T1=Y1-YCEN	RNG	70	
T2=Y2-YCEN	RNG	71	
IF (X1.E0,0.0) X1=0.00001	RNG	72	
IF (X2.E0,0.0) X2=0.00001	RNG	73	
TH1=T1/X1	RNG	74	
TH2=T2/X2	RNG	75	
PHI1=ATAN(TH1)	RNG	76	
PHI2=ATAN(TH2)	RNG	77	
CS1=COS(PHI1)	RNG	78	
SH1=SIN(PHI1)	RNG	79	
CS2=COS(PHI2)	RNG	80	
SH2=SIN(PHI2)	RNG	81	
TL(1,1)=-SH1	RNG	82	
TL(1,2)=+CS1	RNG	83	
TL(2,1)=-CS1	RNG	84	
TL(2,2)=-SH1	RNG	85	
TL(4,4)=-SH2	RNG	86	
TL(4,5)=+CS2	RNG	87	
TL(5,4)=-CS2	RNG	88	
TL(5,5)=-SH2	RNG	89	
TL(6,6)=1.0	RNG	90	
TL(3,3)=TL(6,6)	RNG	91	
CALL MATMULT (SR,TL,TC,6,6)	RNG	92	
CALL MATRMUL (TL,TC,SK,6,6)	RNG	93	
MD=0	RNG	94	
DO 5 I=1,6	RNG	95	
DO 5 J=1,6	RNG	96	
MD=MD+1	RNG	97	
THP(MD)=SK(I,J)	RNG	98	
5 CONTINUE	RNG	99	
CALL WRITMS (7,THP,MD,KI)	RNG	100	
RETURN	RNG	101	
C	RNG	102	
END	RNG	103	
SUBROUTINE JOINT (KI,YCEN,EN,ES,X1,X2,Y1,Y2,TH1,TH2,SKJT)	JHT	2	
DIMENSION SKJT(8,8), TL(8,8), TC(8,8), THP(64)	JHT	3	

EQUIVALENCE (TC(1,1),TMP(1))	JNT	4
	JNT	5
STIFFNESS MATRIX FOR INTERACTION ELEMEN	JNT	6
	JNT	7
PI=22./7.	JNT	8
SPAN=SQRT((X1-X2)**2+(Y1-Y2)**2)	JNT	9
T1=Y1-YCEN	JNT	10
T2=Y2-YCEN	JNT	11
T1=-T1	JNT	12
T2=-T2	JNT	13
IF (T1.EQ.0.0) T1=0.00001	JNT	14
IF (T2.EQ.0.0) T1=0.00001	JNT	15
TN1=ABS(X1/T1)	JNT	16
TN2=ABS(X2/T2)	JNT	17
THETA1=ATAN(TN1)	JNT	18
THETA2=ATAN(TN2)	JNT	19
IF (T1.LT.0.0) THETA1=22./7.-THETA1	JNT	20
IF (T2.LT.0.0) THETA2=22./7.-THETA2	JNT	21
TH1=10.*(THETA1*180./PI)	JNT	22
TH2=10.*(THETA2*180./PI)	JNT	23
CALL NULLMAT (SKJT,8,8)	JNT	24
CS=SPAN*ES/6.	JNT	25
CN=SPAN*EN/6.	JNT	26
SKJT(1,1)=2.*CS	JNT	27
SKJT(1,3)=CS	JNT	28
SKJT(1,5)=-CS	JNT	29
SKJT(1,7)=-2.*CS	JNT	30
SKJT(2,2)=2.*CN	JNT	31
SKJT(2,4)=CN	JNT	32
SKJT(2,6)=-CN	JNT	33
SKJT(2,8)=-2.*CN	JNT	34
SKJT(3,1)=CS	JNT	35
SKJT(3,3)=2.*CS	JNT	36
SKJT(3,5)=-2.*CS	JNT	37
SKJT(3,7)=-CS	JNT	38
SKJT(4,2)=CN	JNT	39
SKJT(4,4)=2.*CN	JNT	40
SKJT(4,6)=-2.*CN	JNT	41
SKJT(4,8)=-CN	JNT	42
SKJT(5,1)=-CS	JNT	43
SKJT(5,3)=-2.*CS	JNT	44
SKJT(5,5)=2.*CS	JNT	45
SKJT(5,7)=CS	JNT	46
SKJT(6,2)=-CN	JNT	47
SKJT(6,4)=-2.*CN	JNT	48
SKJT(6,6)=2.*CN	JNT	49
SKJT(6,8)=CN	JNT	50
SKJT(7,1)=-2.*CS	JNT	51
SKJT(7,3)=-CS	JNT	52
SKJT(7,5)=CS	JNT	53
SKJT(7,7)=2.*CS	JNT	54
SKJT(8,2)=-2.*CN	JNT	55
SKJT(8,4)=-CN	JNT	56
SKJT(8,6)=CN	JNT	57
SKJT(8,8)=2.*CN	JNT	58
CALL NULLMAT (TL,8,8)	JNT	59
CALL NULLMAT (TC,8,8)	JNT	60
CS1=COS(THETA1)	JNT	61
SH1=SIN(THETA1)	JNT	62
CS2=COS(THETA2)	JNT	63


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SN2=SIN(THETA2)                                JNT 64
TL(7,7)=CS1                                     JNT 65
TL(1,1)=TL(7,7)                                JNT 66
TL(7,8)=SN1                                     JNT 67
TL(1,2)=TL(7,8)                                JNT 68
TL(8,7)=-SN1                                    JNT 69
TL(2,1)=TL(8,7)                                JNT 70
TL(8,8)=CS1                                     JNT 71
TL(2,2)=TL(8,8)                                JNT 72
TL(5,5)=CS2                                     JNT 73
TL(3,3)=TL(5,5)                                JNT 74
TL(5,6)=SN2                                     JNT 75
TL(3,4)=TL(5,6)                                JNT 76
TL(6,5)=-SN2                                    JNT 77
TL(4,3)=TL(6,5)                                JNT 78
TL(6,6)=CS2                                     JNT 79
TL(4,4)=TL(6,6)                                JNT 80
CALL MATMULT (SKJT,TL,TC,8,8)                   JNT 81
CALL MATRHUL (TL,TC,SKJT,8,8)                   JNT 82
MO=0                                              JNT 83
DO 5 I=1,8                                       JNT 84
DO 5 J=1,8                                       JNT 85
    MO=MO+1                                       JNT 86
    TMP(MO)=SKJT(I,J)                           JNT 87
5 CONTINUE                                       JNT 88
CALL WRITMS (7,TMP,MO,KI)                       JNT 89
RETURN                                           JNT 90
C                                              JNT 91
END                                              JNT 92
OVERLAY(RDY,4,0)                                STR 1
C                                              STR 2
OVERLAY(RDY,4,0)                                STR 3
PROGRAM STRESS                                  STR 4
COMMON /NODE/ N,ELEMNT,NDOF,NBAND,ND,NT3,ISTOP,NCYCLE,LAYERS,ISTEP,STR 5
1NSTEP,NT12,ETA,NT1,NT2,NDTENS,IFLAG,NSIZE,NCODE(550),X(550),Y(550)STR 6
2),JNDX(51),ANLSIS,IX(8,250),ARENA(250),INDX(250),INDEX(250),GAMA(2STR 7
35),ZAI(3)                                       STR 8
COMMON /1/ E,HUE,RADIUS,XCEN,YCEN,EI,KN,KS,H1,H2,INTER STR 9
COMMON /2/ D                                     STR 10
COMMON /3/ R                                     STR 11
COMMON /4/ MU0U(26),DELTA                       STR 12
COMMON /5/ Q(1100),LIST(1101)                   STR 13
REAL HUE1,HUE2,HUE,HUEK,KS,KN                   STR 14
DIMENSION TEMP(17), R(1100), E(10), HUE(10), D(10,10) STR 15
DIMENSION DMAT(90), UC(12), SKJT(12,12), PP(12), TEMP(17) STR 16
DIMENSION IA(50,4), FR(2)                       STR 17
C                                              STR 18
C *****STR 19
C THIS ROUTINE COMPUTES STRESS, STRAIN, OCTAHEDRAL STRESSES AND STR 20
C STRAINS FROM COMPUTED NODAL DISPLACEMENTS STORED AS R(1) ON TAPE STR 21
C *****STR 22
C STR 23
C PI=22./7.                                       STR 24
CALL ZERO (0,NDOF)                               STR 25
IFLAG=0                                           STR 26
THETA=DELTA*PI/180.                              STR 27
SLIP=TAN(THETA)                                  STR 28
SLIP=1.1*SLIP                                    STR 29
C STR 30
DO 100 KEL=1,ELEMT                                STR 31

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	ITYP=IX(7,KEL)	STR	32
	MT=IX(8,KEL)	STR	33
	GO TO (100,5,35,35,35), ITYP	STR	34
C		STR	35
C	TYPE II INTERACTION ELEMENT	STR	36
C		STR	37
5	CALL ZERO (0,12)	STR	38
	DO 10 I=1,2	STR	39
	DO 10 J=1,2	STR	40
	K=(I-1)*2+J	STR	41
	H=3*IX(I,KEL)-3+J	STR	42
	IA(KEL,I)=H	STR	43
	U(K)=R(N)	STR	44
10	CONTINUE	STR	45
	DO 15 I=3,4	STR	46
	DO 15 J=1,2	STR	47
	K=(I-1)*2+J	STR	48
	H=2*IX(I,KEL)-2+HTO+J	STR	49
	IA(KEL,I)=H	STR	50
	U(K)=R(N)	STR	51
15	CONTINUE	STR	52
	I=IX(1,KEL)	STR	53
	J=IX(2,KEL)	STR	54
	SPAN=SQRT((X(I)-X(J))*2+(Y(I)-Y(J))*2)	STR	55
	TH1=FLOAT(IX(5,KEL))	STR	56
	TH2=FLOAT(IX(6,KEL))	STR	57
	THETA1=TH1*PI/1800.	STR	58
	THETA2=TH2*PI/1800.	STR	59
	CS1=COS(THETA1)	STR	60
	SH1=SIN(THETA1)	STR	61
	CS2=COS(THETA2)	STR	62
	SH2=SIN(THETA2)	STR	63
	CALL ZERO (FP,12)	STR	64
	CALL HULLMAT (SKJT,12,12)	STR	65
	SKJT(7,7)=CS1	STR	66
	SKJT(1,1)=SKJT(7,7)	STR	67
	SKJT(7,8)=SH1	STR	68
	SKJT(1,2)=SKJT(7,8)	STR	69
	SKJT(8,7)=-SH1	STR	70
	SKJT(2,1)=SKJT(8,7)	STR	71
	SKJT(8,8)=CS1	STR	72
	SKJT(2,2)=SKJT(8,8)	STR	73
	SKJT(5,5)=CS2	STR	74
	SKJT(3,3)=SKJT(5,5)	STR	75
	SKJT(5,6)=SH2	STR	76
	SKJT(3,4)=SKJT(5,6)	STR	77
	SKJT(6,5)=-SH2	STR	78
	SKJT(4,3)=SKJT(6,5)	STR	79
	SKJT(6,6)=CS2	STR	80
	SKJT(4,4)=SKJT(6,6)	STR	81
	DO 25 I=1,8	STR	82
	SUM=0.0	STR	83
	DO 20 K=1,8	STR	84
20	SUM=SUM+SKJT(I,K)*U(K)	STR	85
	PP(I)=SUM	STR	86
25	CONTINUE	STR	87
	T1=-PP(1)-PP(3)+PP(5)+PP(7)	STR	88
	T2=-PP(2)-PP(4)+PP(6)+PP(8)	STR	89
	CALL READMS (1,TEMP,17,KEL)	STR	90
	FINN=TEMP(1)	STR	91

	FIXS=TEMP(2)	STR	92
	EN=TEMP(3)	STR	93
	ES=TEMP(4)	STR	94
	PH=0.5*T2*EN/SPAN	STR	95
	PS=0.5*T1*ES/SPAN	STR	96
	TEMP(1)=TEMP(1)+PH	STR	97
	TEMP(2)=TEMP(2)+PS	STR	98
	DO 30 K=5,I2	STR	99
30	TEMP(K)=U(K-4)	STR	100
	TEMP(13)=PS	STR	101
	TEMP(14)=PH	STR	102
	TEMP(15)=FIXS	STR	103
	TEMP(16)=FINN	STR	104
	CALL WRITMS (1,TEMP,17,KEL)	STR	105
	GO TO 100	STR	106
C		STR	107
C		STR	108
C	TYPE III ELEMENT	STR	109
C		STR	110
35	I=IX(1,KEL)	STR	111
	J=IX(2,KEL)	STR	112
	KK=IX(3,KEL)	STR	113
	L=IX(4,KEL)	STR	114
	M=IX(5,KEL)	STR	115
	N=IX(6,KEL)	STR	116
	NK=ITYP-2	STR	117
	GO TO (40,45,50), MK	STR	118
40	I1=2*I-1+NT3	STR	119
	I2=2*J-1+NT3	STR	120
	I3=2*KK-1+NT3	STR	121
	I4=2*L-1+NT3	STR	122
	I5=2*M-1+NT3	STR	123
	I6=2*N-1+NT3	STR	124
	GO TO 55	STR	125
45	I1=3*I-2	STR	126
	I2=3*J-2	STR	127
	I3=2*KK-1+NT3	STR	128
	I4=3*L-2	STR	129
	I5=2*M-1+NT3	STR	130
	I6=2*N-1+NT3	STR	131
	GO TO 55	STR	132
50	I1=2*I-1+NT3	STR	133
	I2=2*J-1+NT3	STR	134
	I3=3*KK-2	STR	135
	I4=2*L-1+NT3	STR	136
	I5=2*M-1+NT3	STR	137
	I6=2*N-1+NT3	STR	138
55	CONTINUE	STR	139
	AA=AREA*(KEL)	STR	140
	YC=(Y(I)+Y(J)+Y(KK))/3.	STR	141
	IF (YC,GT,H2) GO TO 100	STR	142
	CALL READMS (3,DMAT,89,KEL)	STR	143
	D11=DMAT(1)	STR	144
	D12=DMAT(2)	STR	145
	D13=DMAT(3)	STR	146
	D21=DMAT(4)	STR	147
	D22=DMAT(5)	STR	148
	D23=DMAT(6)	STR	149
	D31=DMAT(7)	STR	150
	D32=DMAT(8)	STR	151


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D33=DMAT(9) STR 152
NUE1=DMAT(10) STR 153
NUE2=DMAT(11) STR 154
X21=X(J)-X(I) STR 155
X13=X(I)-X(KK) STR 156
X32=X(KK)-X(J) STR 157
Y23=Y(J)-Y(KK) STR 158
Y31=Y(KK)-Y(I) STR 159
Y12=Y(I)-Y(J) STR 160
U1=R(I1) STR 161
U2=R(I2) STR 162
U3=R(I3) STR 163
U4=R(I4) STR 164
U5=R(I5) STR 165
U6=R(I6) STR 166
V1=R(I1+1) STR 167
V2=R(I2+1) STR 168
V3=R(I3+1) STR 169
V4=R(I4+1) STR 170
V5=R(I5+1) STR 171
V6=R(I6+1) STR 172
C STR 173
CODE=0 STR 174
IF (KEL.GT.NT12.AND.KEL.LE.(NT12+NT1/2)) GO TO 60 STR 175
GO TO 65 STR 176
60 ETATWO=1.-ETA STR 177
ETAFOUR=1.-2.*ETA STR 178
ETA2=ETATWO*ETATWO STR 179
ETA4=ETAFOUR*ETAFOUR STR 180
CODE=1 STR 181
GO TO 70 STR 182
65 MT=IX(8,KEL) STR 183
ETAFOUR=1.0 STR 184
ETATWO=ETAFOUR STR 185
ETA4=1.0 STR 186
ETA2=ETA4 STR 187
C STR 188
C GENERATE AND STORE STRESS AND STRAINS ELEMENT BY ELEMENTC STR 189
C STR 190
70 K=KEL STR 191
F1=(4.*ZAI(1)-ETATWO)/ETATWO STR 192
F2=(4.*ZAI(2)-1.)/ETAFOUR STR 193
F3=4.*ZAI(3)-ETAFOUR STR 194
C STR 195
C STRAINS AT CENTROID STR 196
C STR 197
STRAINX=Y23*F1*U1+Y31*F2*U2+Y12*F3*U3+(Y23*4.*ZAI(2)+Y31*4.*ZAI(1))*U4/ETA2+(Y31*4.*ZAI(3)+Y12*4.*ZAI(2))*U5/ETAFOUR+(Y23*4.*ZSTR 199
2 AI(3)+Y12*4.*ZAI(1))*U6/ETAFOUR STR 200
STRAINX=0.5*STRAINX/AA STR 201
STRAINY=X32*F1*V1+X13*F2*V2+X21*F3*V3+4.*(X32*ZAI(2)+X13*ZAI(1))*V4/ETA2+4.*(X13*ZAI(3)+X21*ZAI(2))*V5/ETAFOUR+4.*(X32*ZAI(3)+STR 203
2 X21*ZAI(1))*V6/ETAFOUR STR 204
STRAINY=0.5*STRAINY/AA STR 205
C STR 206
A1=X32*F1*U1 STR 207
A2=X13*F2*U2 STR 208
A3=X21*F3*U3 STR 209
A4=4.*(X32*ZAI(2)+X13*ZAI(1))*U4/ETA2 STR 210
A5=4.*(X13*ZAI(3)+X21*ZAI(2))*U5/ETAFOUR STR 211

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A6=4.*(X32*ZAI(3)+X21*ZAI(1))*U6/ETAF0UR      STR 212
B1=Y23*F1*V1                                   STR 213
B2=Y31*F2*V2                                   STR 214
B3=Y12*F3*V3                                   STR 215
B4=4.*(Y23*ZAI(2)+Y31*ZAI(1))*V4/ETA2         STR 216
B5=4.*(Y31*ZAI(3)+Y12*ZAI(2))*V5/ETAF0UR      STR 217
B6=4.*(Y23*ZAI(3)+Y12*ZAI(1))*V6/ETAF0UR      STR 218
STRANXY=A1+A2+A3+A4+A5+A6+B1+B2+B3+B4+B5+B6    STR 219
STRANXY=0.5*STRANXY/AF                         STR 220
C                                                STR 221
C                                                STR 222
C      ELEMENT STRESSES AT CENTROID IN X Y AND XY DIRECTIONS STR 223
C                                                STR 224
C      STRESSX=D11*STRAINX+D12*STRAINY+D13*STRANXY STR 225
C      STRESSY=D21*STRAINX+D22*STRAINY+D23*STRANXY STR 226
C      STRESXY=D31*STRAINX+D32*STRAINY+D33*STRANXY STR 227
C                                                STR 228
C      DETERMINE PRINCIPLE STRESSES SIGMA1, SIGMA2,SIGMA3 ... .. STR 229
C                                                STR 230
C      STRESS1=(STRESSX+STRESSY)/2.             STR 231
C      STRESS2=SQRT(((STRESSX-STRESSY)/2. )**2+STRESXY**2) STR 232
C      SIGMA1=STRESS1+STRESS2                   STR 233
C      SIGMA2=(STRESS1-STRESS2)                 STR 234
C      SIGMA2=(SIGMA1+SIGMA3)*(NUE1+NUE2)/2.    STR 235
C                                                STR 236
C      DETERMINE OCTAHEADRAL STRESSES SGMAOCT, TAUOCT ... .. STR 237
C                                                STR 238
C      SGMAOCT=(SIGMA1+SIGMA2+SIGMA3)/3.        STR 239
C      TAUOCT=(SQRT((SIGMA1-SIGMA2)**2+(SIGMA2-SIGMA3)**2+(SIGMA3-SIGMA1)**2))/3. STR 240
1 A1)**2))/3.                                   STR 241
C                                                STR 242
C      DETERMINE PRINCIPLE STRAINS EPLISH1, EPLISH2, EPLISH3 ... .. STR 243
C                                                STR 244
C      E1=(STRAINX+STRAINY)/2.                 STR 245
C      E2=SQRT(((STRAINX-STRAINY)/2. )**2+STRANXY**2) STR 246
C      EPLISH1=E1+E2                           STR 247
C      EPLISH3=E1-E2                           STR 248
C      EPLISH2=(EPLISH1+EPLISH3)*(NUE1+NUE2)/2. STR 249
C                                                STR 250
C      DETERMINE OCTAHEADRAL STRAINS - EPSNOCT, GAMAOCT ... .. STR 251
C                                                STR 252
C      EPSNOCT=(EPLISH1+EPLISH2+EPLISH3)/3.     STR 253
C      GAMAOCT=2.*(SQRT((EPLISH1-EPLISH2)**2+(EPLISH2-EPLISH3)**2+(EPLISH3-EPLISH1)**2))/3. STR 254
1 ISN3-EPLISH1)**2))/3.                       STR 255
C                                                STR 256
C      STORE STRESSES AND STRAINS ON TAPE 1     STR 257
C                                                STR 258
C      CALL READMS (1,TEMP,17,KEL)             STR 259
C      DELSIG1=SIGMA1                          STR 260
C      SIG1=TEMP(4)                             STR 261
C      STRESSX=STRESSX+TEMP(1)                  STR 262
C      STRESSY=STRESSY+TEMP(2)                  STR 263
C      STRESXY=STRESXY+TEMP(3)                  STR 264
C      SIGMA1=SIGMA1+TEMP(4)                    STR 265
C      SIGMA2=SIGMA2+TEMP(5)                    STR 266
C      SIGMA3=SIGMA3+TEMP(6)                    STR 267
C      SGMAOCT=SGMAOCT+TEMP(7)                  STR 268
C      TAUOCT=TAUOCT+TEMP(8)                    STR 269
C      STRAINX=STRAINX+TEMP(9)                  STR 270
C      STRAINY=STRAINY+TEMP(10)                 STR 271

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	STRANKY=STRANKY+TEMP(11)	STR	272
	EPLISH1=EPLISH2+TEMP(12)	STR	273
	EPLISH2=EPLISH2+TEMP(13)	STR	274
	EPLISH3=EPLISH3+TEMP(14)	STR	275
	EPSNDOCT=EPSNDOCT+TEMP(15)	STR	276
	GAMADCT=GAMADCT+TEMP(16)	STR	277
C		STR	278
	TEMP(1)=STRESSX	STR	279
	TEMP(2)=STRESSY	STR	280
	TEMP(3)=STRESSZ	STR	281
	TEMP(4)=SIGMA1	STR	282
	TEMP(5)=SIGMA2	STR	283
	TEMP(6)=SIGMA3	STR	284
	TEMP(7)=SGMADCT	STR	285
	TEMP(8)=TAUDCT	STR	286
	TEMP(9)=STRAINX	STR	287
	TEMP(10)=STRAINY	STR	288
	TEMP(11)=STRANKY	STR	289
	TEMP(12)=EPLISH1	STR	290
	TEMP(13)=EPLISH2	STR	291
	TEMP(14)=EPLISH3	STR	292
	TEMP(15)=EPSNDOCT	STR	293
	TEMP(16)=GAMADCT	STR	294
C		STR	295
	CALL WRITMS (1,TEMP,17,KEL)	STR	296
C		STR	297
	IF (NOTENSH.LE.0) GO TO 100	STR	298
C		STR	299
C	NO-TENSION ANALYSIS	STR	300
C		STR	301
	SIGTOTL=SIG1+DELSIG1	STR	302
	IF (SIGTOTL+GAMA(MT)) 75,100,100	STR	303
75	WRITE (6,165) KEL,SIG1,DELSIG1	STR	304
	CALL ZERO (PP,12)	STR	305
	CALL NULLMAT (SKJT,12,12)	STR	306
	RATIO=1.-ABS(SIG1)/ABS(DELSIG1)	STR	307
	MD=11	STR	308
	DO 85 IM=1,12	STR	309
	DO 80 JM=IM,12	STR	310
	MD=MD+1	STR	311
80	SKJT(IM,JM)=SKJT(JM,IM)=IMAT(MD)	STR	312
85	CONTINUE	STR	313
	U(1)=U1	STR	314
	U(2)=U2	STR	315
	U(3)=U3	STR	316
	U(4)=U4	STR	317
	U(5)=U5	STR	318
	U(6)=U6	STR	319
	U(7)=V1	STR	320
	U(8)=V2	STR	321
	U(9)=V3	STR	322
	U(10)=V4	STR	323
	U(11)=V5	STR	324
	U(12)=V6	STR	325
	DO 95 JI=1,12	STR	326
	SUM=0.0	STR	327
	DO 90 KI=1,12	STR	328
90	SUM=SUM+SKJT(JI,KI)*U(KI)	STR	329
	PP(JI)=-SUM*RATIO	STR	330
95	CONTINUE	STR	331

C	Q(I1)=Q(I1)+PP(1)	STR 332
	Q(I2)=Q(I2)+PP(2)	STR 333
	Q(I3)=Q(I3)+PP(3)	STR 334
	Q(I4)=Q(I4)+PP(4)	STR 335
	Q(I5)=Q(I5)+PP(5)	STR 336
	Q(I6)=Q(I6)+PP(6)	STR 337
	Q(I1+1)=Q(I1+1)+PP(7)	STR 338
	Q(I2+1)=Q(I2+1)+PP(8)	STR 339
	Q(I3+1)=Q(I3+1)+PP(9)	STR 340
	Q(I4+1)=Q(I4+1)+PP(10)	STR 341
	Q(I5+1)=Q(I5+1)+PP(11)	STR 342
	Q(I6+1)=Q(I6+1)+PP(12)	STR 343
	IFLAG=1	STR 344
		STR 345
C		STR 346
100	CONTINUE	STR 347
	IF (NT3.LE.0) GO TO 160	STR 348
	IF (INTER.LE.0) GO TO 160	STR 349
C		STR 350
C	HO-TENSION ANALYSIS FOR INTERACTION ELEMENT	STR 351
C		STR 352
	NSTART=NT1+1	STR 353
	DO 155 KEL=NSTART,NT12,2	STR 354
	MT=IX(8,KEL)	STR 355
	FR(2)=0.0	STR 356
	FR(1)=FR(2)	STR 357
	CALL READMS (1,TEMP,17,KEL)	STR 358
	CALL READMS (1,TEMP,17,KEL+1)	STR 359
	PNORML=(TEMP(1)+TEMP(17))*0.5	STR 360
	PSHEAR=(TEMP(2)+TEMP(17))*0.5	STR 361
	IF (ABS(PNORML).LT.GAMMA(MT)) GO TO 155	STR 362
	IF (PNORML+GAMMA(MT)) 110,105,105	STR 363
105	IF (NCYCLE.EQ.1) GO TO 155	STR 364
	RATIO=ABS(PSHEAR/PNORML)	STR 365
	IF (RATIO.LE.SLIP) GO TO 155	STR 366
	R1=ABS(TEMP(15)/TEMP(16))	STR 367
	Q0=TEMP(13)/TEMP(14)	STR 368
	FIXN=TEMP(16)	STR 369
	PN=TEMP(14)	STR 370
	DR=SLIP-R1	STR 371
	T3=Q0-R1-DR	STR 372
	DSR=DR*FIXN/T3	STR 373
	T4=(PN-DSR)/PN	STR 374
	FR(1)=T4+FR(1)	STR 375
	FR(1)=-FR(1)	STR 376
	WRITE (6,170) KEL,RATIO,SLIP,R1,Q0,DR,DSR,FIXN,PN,FR(1)	STR 377
	R1=ABS(TEMP(15)/TEMP(16))	STR 378
	Q0=TEMP(13)/TEMP(14)	STR 379
	FIXN=TEMP(16)	STR 380
	PN=TEMP(14)	STR 381
	DR=SLIP-R1	STR 382
	T3=Q0-R1-DR	STR 383
	DSR=DR*FIXN/T3	STR 384
	T4=(PN-DSR)/PN	STR 385
	FR(2)=T4+FR(2)	STR 386
	FR(2)=-FR(2)	STR 387
	KEL1=KEL+1	STR 388
	WRITE (6,170) KEL1,RATIO,SLIP,R1,Q0,DR,DSR,FIXN,PN,FR(2)	STR 389
	GO TO 115	STR 390
C		STR 391

110	T1=(TEMP(16)+TEMP(16))/2.	STR	392
	T2=(TEMP(14)+TEMP(14))/2.	STR	393
C		STR	394
C	FR(1)=FR(2)=1,-ABS(T1)/ABS(T2)	STR	395
C		STR	396
	T3=1.-T1/T2	STR	397
	FR(2)=T3/2.	STR	398
	FR(1)=FR(2)	STR	399
	KEL1=KEL+1	STR	400
	WRITE (6,175) KEL,KEL1,FR(1),FR(2)	STR	401
115	NUM=KEL	STR	402
	ND=1	STR	403
120	CALL READHS (7,DMAT,6*,NUM)	STR	404
	MD=0	STR	405
	DO 125 IM=1,8	STR	406
	DO 125 JM=1,8	STR	407
	MD=MD+1	STR	408
	SKJT(IM,JM)=DMAT(MD)	STR	409
125	CONTINUE	STR	410
	DO 140 IM=1,8	STR	411
	GO TO (130,135), ND	STR	412
130	U(IM)=TEMP(IM+4)	STR	413
	GO TO 140	STR	414
135	U(IM)=TEMP(IM+4)	STR	415
140	CONTINUE	STR	416
	DO 150 JI=1,8	STR	417
	SUM=0.0	STR	418
	DO 145 KI=1,8	STR	419
145	SUM=SUM+SKJT(JI,KI)*U(KI)	STR	420
C		STR	421
C	PP(JI)=-SUM * FR(ND)	STR	422
C		STR	423
	PP(JI)=SUM*FR(ND)	STR	424
150	CONTINUE	STR	425
	WRITE (6,180) (PP(JI),JI=1,8)	STR	426
	I1=IA(NUM,1)	STR	427
	I2=IA(NUM,2)	STR	428
	I3=IA(NUM,3)	STR	429
	I4=IA(NUM,4)	STR	430
C		STR	431
	Q(I1)=Q(I1)+PP(1)	STR	432
	Q(I1+1)=Q(I1+1)+PP(2)	STR	433
	Q(I2)=Q(I2)+PP(3)	STR	434
	Q(I2+1)=Q(I2+1)+PP(4)	STR	435
	Q(I3)=Q(I3)+PP(5)	STR	436
	Q(I3+1)=Q(I3+1)+PP(6)	STR	437
	Q(I4)=Q(I4)+PP(7)	STR	438
	Q(I4+1)=Q(I4+1)+PP(8)	STR	439
	IFLAG=1	STR	440
	ND=ND+1	STR	441
	IF (ND,GT,2) GO TO 155	STR	442
	NUM=KEL+1	STR	443
	GO TO 120	STR	444
155	CONTINUE	STR	445
160	WRITE (6,185)	STR	446
	RETURN	STR	447
C		STR	448
165	FORMAT (10X, 24HTENSION IN ELEMENT ND = ,I5, 8H SIGMA1=,E12.3, 13STR	STR	449
	1H DELSIGMA1 = ,E12.3)	STR	450
170	FORMAT (1X, 8HINT SLIP,I5,9E12.3)	STR	451

	WRITE (6,110) I,R(K1),R(K2),I1,R(K3),R(K4),I2,R(K5),R(K6)	RES	57
	25 CONTINUE	RES	58
C		RES	59
C	PRINT ELEMENT STRESSES	RES	60
C		RES	61
	WRITE (6,115)	RES	62
	NT12P1=NT12+1	RES	63
	DO 30 I=NT12P1,NELEMT.	RES	64
	CALL READMS (1,TEMP,17,I)	RES	65
	WRITE (6,120) (I,(TEMP(J),J=1,8))	RES	66
	30 CONTINUE	RES	67
C		RES	68
C	CALCULATION OF NORMAL, SHEAR FORCE AND MOMENTS FOR PIPE NODES	RES	69
C		RES	70
	85 IF (NT3.LE.0) GO TO 85	RES	71
	WRITE (6,125)	RES	72
	NEL=NT3-1	RES	73
	DO 55 I=1,NEL	RES	74
	IF (IX(7,I),NE,1) GO TO 55	RES	75
	I1=IX(1,I)	RES	76
	I2=IX(2,I)	RES	77
	U1=3*(I1-1)+1	RES	78
	U2=U1+1	RES	79
	U3=U1+2	RES	80
	U4=3*(I2-1)+1	RES	81
	U5=U4+1	RES	82
	U6=U4+2	RES	83
	U(1)=S1(U1)	RES	84
	U(2)=S1(U2)	RES	85
	U(3)=S1(U3)	RES	86
	U(4)=S1(U4)	RES	87
	U(5)=S1(U5)	RES	88
	U(6)=S1(U6)	RES	89
	CALL READMS (7,TMP,36,I)	RES	90
C		RES	91
	MD=0	RES	92
	CALL READMS (1,TEMP,17,I)	RES	93
	DO 40 K=1,6	RES	94
	DO 40 L=1,6	RES	95
	MD=MD+1	RES	96
	SRG(K,L)=TMP(MD)	RES	97
40	CONTINUE	RES	98
	DO 50 K=1,6	RES	99
	SUM=0.0	RES	100
	DO 45 L=1,6	RES	101
45	SUM=SUM+SRG(K,L)*U(L)	RES	102
	PP(K)=SUM	RES	103
50	CONTINUE	RES	104
	PXY(I1)=PP(4)+TEMP(3)	RES	105
	QXY(I1)=PP(5)+TEMP(4)	RES	106
	MDK(I1)=PP(6)+TEMP(5)	RES	107
	PXY(I2)=PP(1)+TEMP(6)	RES	108
	QXY(I2)=PP(2)+TEMP(7)	RES	109
	MDK(I2)=PP(3)+TEMP(8)	RES	110
	TEMP(3)=PXY(I1)	RES	111
	TEMP(4)=QXY(I1)	RES	112
	TEMP(5)=MDK(I1)	RES	113
	TEMP(6)=PXY(I2)	RES	114
	TEMP(7)=QXY(I2)	RES	115
	TEMP(8)=MDK(I2)	RES	116


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      CALL WRITMS (1,TEMP,17,I)                                RES 117
55 CONTINUE                                                    RES 118
      DO 70 I=1,NT3                                           RES 119
        IF (1.EQ.NT3) GO TO 60                                RES 120
        GO TO 65                                              RES 121
60      PXY(I)=-PXY(I)                                         RES 122
        QXY(I)=-QXY(I)                                         RES 123
        MOM(I)=-MOM(I)                                         RES 124
65      YC=Y(I)-YCEH                                           RES 125
        XC=X(I)-XCEH                                           RES 126
        IF (XC.EQ.0.0) XC=0.00001                             RES 127
        TH=YC/XC                                               RES 128
        THETA=ATAN(TH)                                          RES 129
        SH=SIN(THETA)                                          RES 130
        CS=COS(THETA)                                          RES 131
        P(I)=-PXY(I)*SH+QXY(I)*CS                             RES 132
        Q(I)=-PXY(I)*CS+QXY(I)*SH                             RES 133
        WRITE (6,130) I,P(I),Q(I),MOM(I)                     RES 134
70 CONTINUE                                                    RES 135
      WRITE (6,140)                                             RES 136
      NSTART=NT1+1                                             RES 137
      DO 75 I=NSTART,NT12,2                                     RES 138
        CALL READMS (1,TEMP,17,I)                             RES 139
        T1=TEMP(1)                                             RES 140
        T2=TEMP(2)                                             RES 141
        CALL READMS (1,TEMP,17,I+1)                           RES 142
        TEMP(1)=0.5*(T1+TEMP(1))                             RES 143
        TEMP(2)=0.5*(T2+TEMP(2))                             RES 144
        RATIO=ABS(TEMP(2)/TEMP(1))                             RES 145
        IP1=I+1                                                RES 146
        WRITE (6,135) I,IP1,TEMP(1),TEMP(2),RATIO            RES 147
75 CONTINUE                                                    RES 148
C                                                                    RES 149
C                                                                    RES 150
C                                                                    RES 151
      WRITE (6,145)                                             RES 152
      DO 80 I=NT12P1,NELEMT                                     RES 153
        CALL READMS (1,TEMP,17,I)                             RES 154
        WRITE (6,120) (I,(TEMP(J),J=9,16))                   RES 155
80 CONTINUE                                                    RES 156
85 WRITE (6,150)                                               RES 157
      RETURN                                                    RES 158
C                                                                    RES 159
90 FORMAT (1H1,10X, 14HRESULTS AFTER ,I5, 17H LAYERS OF FILL,5X, 15RES 160
1HINCREMENT NO = ,I5//)                                       RES 161
95 FORMAT (10X, 28H3 - D.O.F. NODAL DEFLECTIONS,//10X, 8HNODE NO.,5XRES 162
1, 14HX - DEFLECTION,5X, 14HY - DEFLECTION,5X, 8HROTATION,/)   RES 163
100 FORMAT (7X,I5,7X,3(E14.4,5X))                             RES 164
105 FORMAT (//10X, 21HNODE POINT DEFLECTION,//3(3X, 8HNODE NO.,3X, 12RES 165
1HX-DEFLECTION,3X, 12HY-DEFLECTION)//)                         RES 166
110 FORMAT (3(5X,14,5X,E12.4, 3X,E12.4))                     RES 167
115 FORMAT (1H1,10X, 16HELEMENT STRESSES,//5X, 11HELEMENT NO.,3X, 7HSRES 168
1TRESSX,7X, 7HSTRESSY,7X, 7HSTRESSXY,7X, 6HSIGMA1,8X, 6HSIGMA2,8RES 169
2X, 6HSIGMA3,7X, 8HSIGMACT,6X, 7HTAUDELTA,/)                 RES 170
120 FORMAT (5X,I5,2X,8E14.2)                                   RES 171
125 FORMAT (//10X, 47HNORMAL AND SHEAR FORCES, MOMENTS AT PIPE NODES,RES 172
1/10X, 8HNODE NO.,10X, 12HNORMAL FORCE,5X, 11HSHEAR FORCE,5X, 12HNRES 173
2ODAL MOMENT,/)                                               RES 174
130 FORMAT (13X,I3,12X,E12.2,2(4X,E12.2))                   RES 175
135 FORMAT (3X,I2, 3H + ,I2,12X,E10.2,12X,E10.2,12X,F10.4)   RES 176

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140 FORMAT (////10%, 52HNORMAL AND SHEAR STRESS ON SOIL IN INTERACTION RES 177
1LAYER,///5%, 7HELE.ND.,10%, 12HNORMAL STRS.,10%, 12HSHEAR STRESS,1RES 178
20%, 12H RATIO T/H ,//) RES 179
145 FORMAT (1H1/10%, 15HELEMENT STRAINS,///5%, 11HELEMENT NO.,3%, 7HSTRES 180
1RAINX,7%, 7HSTRAINX,7%, 7HSTRAINX,7%, 7HEPSILN1,7%, 7HEPSILN2,RES 181
27%, 7HEPSILN3,7%, 7HEPSINDCT,7%, 7HGAMADCT,/) RES 182
150 FORMAT (1X, 23HOVERLAY (%.0) COMPLETED) RES 183
C RES 184
END RES 185
OVERLAY(RDY,6,0) SOL 1
C OVERLAY(RDY,6,0) SOL 2
PROGRAM RESOLV SOL 3
COMMON NNODES,NELEMNT,NDOF,HEARD,ND,NT3,ISTDP,NCYCLE,LAYERS,ISTEP,SOL 4
1NSTEP,NT12,ETA,NT1,NT2,NOTENSN, FLAG,NSIZE,MCODE(550),X(550),Y(550,SOL 5
2),JNDX(51),ANLS13,IX(8,250),AREAA(250),INDX(250),INDEX(250),GAMA(250,SOL 6
35),ZAI(3) SOL 7
COMMON /3/ R SOL 8
COMMON /5/ Q(1100),LIST(1101) SOL 9
DIMENSION A(103,206), B(206), APRAY(103) SOL 10
DIMENSION R(1100) SOL 11
REWIND 9 SOL 12
C SOL 13
C SOLUTION OF STIFFNESS EQUATIONS FOR GIVEN BOUNDARY CONDITIONS AND SOL 14
C SOL 15
HUMBLK=1 SOL 16
NL=1 SOL 17
NM=ND SOL 18
KSHIFT=0 SOL 19
ND2=2*ND SOL 20
NEND=3*NT3 SOL 21
NDINC=1 SOL 22
IF (NT3.LE.0) NDINC=0 SOL 23
IF (NT3.LE.0) ND=ND-1 SOL 24
CALL NULLMAT (A,ND,ND2) SOL 25
CALL ZERO (B,ND2) SOL 26
NX=NL-1 SOL 27
CALL ZERO (ARRAY,NSIZE) SOL 28
DO 10 N=1,NSIZE SOL 29
CALL READMS (10,ARRAY,NSIZE,NX+N) SOL 30
DO 5 M=1,NSIZE SOL 31
A(N,M)=ARRAY(M) SOL 32
10 CONTINUE SOL 33
GO TO 30 SOL 34
15 NX=NL-1 SOL 35
CALL ZERO (ARRAY,NSIZE) SOL 36
DO 25 N=1,NSIZE SOL 37
CALL READMS (10,ARRAY,NSIZE,NX+N) SOL 38
DO 20 M=1,NSIZE SOL 39
A(N,M)=A(N,M)+ARRAY(M) SOL 40
25 CONTINUE SOL 41
C SOL 42
C MODIFICATION FOR LOAD AND BOUNDARY CONDITIONS SOL 43
C SOL 44
30 I=NL SOL 45
35 IF (I.GT.NEND) GO TO 70 SOL 46
FIND=FLOAT(I+2)/3. SOL 47
II=INT(FIND) SOL 48
PX=Q(I) SOL 49
PY=Q(I+1) SOL 50
ICODE=NCODE(II)-3 SOL 51

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	GO TO (40,45,50,55,60,65), ICODE	SOL	52
40	J=I-KSHIFT	SOL	53
	B(J)=B(J)+PX	SOL	54
	B(J+1)=B(J+1)+PY	SOL	55
	I=I+3	SOL	56
	GO TO 35	SOL	57
45	J=I-KSHIFT	SOL	58
	P=0.0	SOL	59
	CALL MODIFY (J,ND,P,A,B)	SOL	60
	B(J+1)=B(J+1)+PY	SOL	61
	I=I+3	SOL	62
	GO TO 35	SOL	63
50	J=I-KSHIFT	SOL	64
	B(J)=B(J)+PX	SOL	65
	P=0.0	SOL	66
	CALL MODIFY (J+1,ND,P,A,B)	SOL	67
	I=I+3	SOL	68
	GO TO 35	SOL	69
55	J=I-KSHIFT	SOL	70
	B(J)=B(J)+PX	SOL	71
	B(J+1)=B(J+1)+PY	SOL	72
	P=0.0	SOL	73
	CALL MODIFY (J+2,ND,P,A,B)	SOL	74
	I=I+3	SOL	75
	GO TO 35	SOL	76
60	J=I-KSHIFT	SOL	77
	P=0.0	SOL	78
	CALL MODIFY (J,ND,P,A,B)	SOL	79
	B(J+1)=B(J+1)+PY	SOL	80
	CALL MODIFY (J+2,ND,P,A,B)	SOL	81
	I=I+3	SOL	82
	GO TO 35	SOL	83
65	J=I-KSHIFT	SOL	84
	B(J)=B(J)+PX	SOL	85
	P=0.0	SOL	86
	CALL MODIFY (J+1,ND,P,A,B)	SOL	87
	CALL MODIFY (J+2,ND,P,A,B)	SOL	88
	I=I+3	SOL	89
	GO TO 35	SOL	90
70	IF (I.GT.NM.OR.I.GT.NDOF) GO TO 95	SOL	91
	FIND=FLOAT(I-RT3+1)/2.	SOL	92
	II=INT(FIND)	SOL	93
	PX=Q(I)	SOL	94
	PY=Q(I+1)	SOL	95
	ICODE=NCODE(II)+1	SOL	96
	GO TO (75,80,85,90), ICODE	SOL	97
75	J=I-KSHIFT	SOL	98
	B(J)=B(J)+PX	SOL	99
	B(J+1)=B(J+1)+PY	SOL	100
	I=I+2	SOL	101
	GO TO 70	SOL	102
80	J=I-KSHIFT	SOL	103
	P=0.0	SOL	104
	CALL MODIFY (J,ND,P,A,B)	SOL	105
	B(J+1)=B(J+1)+PY	SOL	106
	I=I+2	SOL	107
	GO TO 70	SOL	108
85	J=I-KSHIFT	SOL	109
	B(J)=B(J)+PX	SOL	110
	P=0.0	SOL	111

	CALL MODIFY (J+1,ND,P,A,B)	SOL	112
	I=I+2	SOL	113
	GO TO 70	SOL	114
90	J=I-KSHIFT	SOL	115
	P=0.0	SOL	116
	CALL MODIFY (J,ND,P,A,B)	SOL	117
	CALL MODIFY (J+1,ND,P,A,B)	SOL	118
	I=I+2	SOL	119
	GO TO 70	SOL	120
95	CONTINUE	SOL	121
C		SOL	122
C	REDUCE BLOCK OF EQUATIONS	SOL	123
C		SOL	124
	DO 110 N=1,ND	SOL	125
	IF (A(1,N),EQ,0.0) GO TO 110	SOL	126
	B(N)=B(N)/A(1,N)	SOL	127
	DO 105 L=2,MBAND	SOL	128
	IF (A(L,N),EQ,0.0) GO TO 105	SOL	129
	CX=A(L,N)/A(1,N)	SOL	130
	I=N+L-1	SOL	131
	J=0	SOL	132
	DO 100 K=L,MBAND	SOL	133
	J=J+1	SOL	134
100	A(J,I)=A(J,I)-CX*A(K,N)	SOL	135
	B(I)=B(I)-A(L,N)*B(N)	SOL	136
	A(L,N)=CX	SOL	137
105	CONTINUE	SOL	138
110	CONTINUE	SOL	139
	IF (NM,GE,NDOF) GO TO 120	SOL	140
C		SOL	141
C	WRITE BLOCK OF EQUATIONS (REDUCED) ON TAPE 9	SOL	142
C		SOL	143
	WRITE (9) (B(N), (A(M,N),M=1,MBAND),N=1,ND)	SOL	144
C		SOL	145
C	SHIFT BLOCK OF EQN. UP FOR NEXT BLOCK	SOL	146
C		SOL	147
	DO 115 N=1,ND	SOL	148
	MM=ND+N	SOL	149
	B(MM)=B(N)	SOL	150
	B(NM)=0.0	SOL	151
	DO 115 M=1,MBAND	SOL	152
	A(M,N)=A(M,MM)	SOL	153
	A(M,MM)=0.0	SOL	154
115	CONTINUE	SOL	155
	KSHIFT=KSHIFT+ND	SOL	156
	IF (NUMBLK,EQ,1) ND=ND-MRINC	SOL	157
	NUMBLK=NUMBLK+1	SOL	158
	NM=NM+ND	SOL	159
	NL=NM-ND+1	SOL	160
	GO TO 15	SOL	161
C		SOL	162
C	BACK SUBSTITUTION IN GAUSS ELIMINATION PROCESS	SOL	163
C		SOL	164
	120 CALL ZERO (R,NDOF)	SOL	165
	IF (NUMBLK,EQ,1) NDINC=0	SOL	166
C		SOL	167
	NU=ND*NUMBLK+1+NDINC	SOL	168
	NB=NUMBLK	SOL	169
125	DO 135 M=1,ND	SOL	170
	N=ND+1-M	SOL	171

	DO 130 K=2,MBAND	SOL	172
	L=N+K-1	SOL	173
130	B(N)=B(N)-A(K,H)*B(L)	SOL	174
	NM=N+HD	SOL	175
	IF (NB.EQ.2) NM=NM+NDINC	SOL	176
	B(NM)=B(N)	SOL	177
	NU=NU-1	SOL	178
135	R(NU)=B(N)	SOL	179
	NB=NB-1	SOL	180
	IF (NB.EQ.1) ND=ND+NDINC	SOL	181
	IF (NB.LE.0) GO TO 140	SOL	182
	BACKSPACE 9	SOL	183
	READ (9) (B(ND), (A(M,N),M=1,MBAND),N=1,ND)	SOL	184
	BACKSPACE 9	SOL	185
	GO TO 125	SOL	186
140	CONTINUE	SOL	187
	RETURN	SOL	188
C		SOL	189
C		SOL	190
	END	SOL	191
	SUBROUTINE MODIFY (N,ND,P,A,B)		2
	DIMENSION A(103,206), B(206)		3
C			4
C	MODIFICATION FOR BOUNDARY CONDITIONS		5
C			6
	ND2=2*ND		7
	DO 10 M=2,HD		8
	K=N-M+1		9
	IF (K.LE.0) GO TO 5		10
	B(K)=B(K)-A(M,K)*P		11
	A(M,K)=0.0		12
5	K=N+M-1		13
	IF (K.GT.ND2) GO TO 10		14
	B(K)=B(K)-A(M,N)*P		15
	A(M,N)=0.0		16
10	CONTINUE		17
	A(1,N)=0.0		18
	B(N)=0.0		19
	RETURN		20
C			21
	END		22

APPENDIX - II

PROPERTY PROGRAM LISTING

	PROGRAM PROPERTY (INPUT,OUTPUT)	PRO	2
	DIMENSIOND XP(20), YP(20), VP(20), YDP1(20), YDPV(20), TITL(10)	PRO	3
	REAL NUE,NUEIN	PRO	4
	DATA PLSTRS,PLSTRN/6HPLSTRS,6HPLSTRN/	PRO	5
C		PRO	6
C	THIS PROGRAM GENERATES DATA REQUIRED FOR EVALUATION OF TANGENT	PRO	7
C	MODULUS AND POISSONS RATIO VS. SIGMA(OCT) FOR VARIOUS STRESS RATIO	PRO	8
C		PRO	9
	READ 70, (TITL(I),I=1,10)	PRO	10
	READ 75, TEST,NDCURVS,RF	PRO	11
	IF (TEST.EQ.PLSTRS) NGO=1	PRO	12
	IF (TEST.EQ.PLSTRN) NGO=2	PRO	13
	DO 65 IX=1,NDCURVS	PRO	14
	READ 80, SIGMA3,NP	PRO	15
	READ 85, (XP(I),YP(I),VP(I),I=1,NP)	PRO	16
	PRINT 70, (TITL(I),I=1,10)	PRO	17
	PRINT 90, IX,SIGMA3,NP,RF	PRO	18
	PRINT 95, (I,XP(I),YP(I),VP(I),I=1,NP)	PRO	19
	DO 5 I=1,NP	PRO	20
5	VP(I)=VP(I)-XP(I)	PRO	21
	S1IN=SIGMA3	PRO	22
	XIN=0.0	PRO	23
	E3IN=0.0	PRO	24
	CALL SPLINE (NP,XP,YP,YDP1)	PRO	25
	CALL SPLINE (NP,XP,VP,YDPV)	PRO	26
	PRINT 100	PRO	27
	X=0.00001	PRO	28
	DX=0.000001	PRO	29
	NUE=0.5	PRO	30
10	DO 15 L=2,NP	PRO	31
	IF (X.LT.XP(L).AND.X.GE.XP(L-1)) GO TO 20	PRO	32
15	CONTINUE	PRO	33
	GO TO 65	PRO	34
20	A=YDP1(L-1)	PRO	35
	B=YDP1(L)	PRO	36
	C=XP(L-1)	PRO	37
	D=XP(L)	PRO	38
	E=YP(L-1)	PRO	39
	F=YP(L)	PRO	40
	PP=X	PRO	41
	S1=ORDINET(A,B,C,D,E,F,PP)	PRO	42
C		PRO	43
	DO 25 L=2,NP	PRO	44
	IF (X.LT.XP(L).AND.X.GE.XP(L-1)) GO TO 30	PRO	45
25	CONTINUE	PRO	46
	GO TO 65	PRO	47
30	A=YDPV(L-1)	PRO	48
	B=YDPV(L)	PRO	49
	C=XP(L-1)	PRO	50
	D=XP(L)	PRO	51
	E=VP(L-1)	PRO	52
	F=VP(L)	PRO	53
	PP=X	PRO	54
	E3=ORDINET(A,B,C,D,E,F,PP)	PRO	55
	B1=S1+SIGMA3	PRO	56
	B3=SIGMA3	PRO	57
	GO TO (35,40), NGO	PRO	58
35	B2=B3	PRO	59
	GO TO 45	PRO	60


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40      B2=HUE*(B1+B3)                                PRO 61
45      SGMAOCT=(B1+B2+B3)/3.                          PRO 62
      A1=B1-B2                                          PRO 63
      A2=B2-B3                                          PRO 64
      A3=B3-B1                                          PRO 65
      TAUOCT=0.333*SQRT(A1**2+A2**2+A3**2)            PRO 66
      T1=X                                              PRO 67
      T3=E3                                             PRO 68
      GO TO (50,55), NGD                               PRO 69
50      T2=T3                                           PRO 70
      GO TO 60                                          PRO 71
55      T2=0.0                                          PRO 72
60      A1=T1-T2                                         PRO 73
      A2=T2-T3                                         PRO 74
      A3=T3-T1                                         PRO 75
      GAMAOCT=2.*(SQRT(A1**2+A2**2+A3**2))/3.         PRO 76
      TAU=RF*SGMAOCT                                   PRO 77
      RATIO=TAUOCT/TAU                                  PRO 78
      EP3=E3                                           PRO 79
      T1=SIGMA3*X-B1*EP3                               PRO 80
      T2=(SIGMA3+B1)*(X-EP3)                          PRO 81
      NUE=T1/T2                                         PRO 82
      EM1=B1*(1.-NUE**2)/X                             PRO 83
      EM2=NUE*(1.+NUE)*SIGMA3/X                       PRO 84
      EM=EM1-EM2                                       PRO 85
      EM=100.*EM                                       PRO 86
      DS1=S1-S1IN                                       PRO 87
      DEP1=X-XIN                                       PRO 88
      DEP3=EP3-E3IN                                     PRO 89
      T1=DS1/(DEP1-DEP3)                               PRO 90
      T2=DEP3/(DEP1-DEP3)                             PRO 91
      TMOD=T1*(1.-T2)                                  PRO 92
      TMOD=100.*TMOD                                    PRO 93
      TANNUE=-DEP3/(DEP1-DEP3)                         PRO 94
      PRINT 105, X, E3, S1, TAUOCT, GAMAOCT, NUE, EM, TANNUE, SGMAOCT, TMOD, RATIO PRO 95
1      TID                                             PRO 96
      XIN=X                                             PRO 97
      S1IN=S1                                           PRO 98
      E3IN=EP3                                          PRO 99
      DX=1.*DX                                          PRO 100
      X=X+DX                                            PRO 101
      IF (X.GT.XP(NP)) GO TO 65                       PRO 102
      GO TO 10                                          PRO 103
65      CONTINUE                                       PRO 104
      STOP                                              PRO 105
C
70      FORMAT (10A8)                                  PRO 106
75      FORMAT (A6,I3,F10.0)                          PRO 107
80      FORMAT (5X,F10.0,I5)                          PRO 108
85      FORMAT (3F5.0)                                 PRO 109
90      FORMAT (10X, 12H CURVE NO. = ,I5, 11H SIGMA3 = ,F8.2, 16H NO. OF POPPRD PRO 110
      1INTS = ,I5, 18H FAILURE RATIO = ,F8.2/10X, 10H INPUT DATA,/2X, 6HPRO 111
      2SL.NO.,4X, 7H STRAIN1,8X, 5HS1-S3,6X, 7H STRAIN3,3X, 11H( PERCENTPRO 112
      3 ))                                             PRO 113
95      FORMAT (4X,I2,4X,3E12.3)                     PRO 114
100     FORMAT (3X, 7H STRAIN1,5X, 7H STRAIN3,5X, 6HSIGMA1,7X, 6HTAUOCT,PRO 115
      16X, 7HGAMAOCT,6X, 3HNUE,7X, 7HMODULUS,4X, 6HTANNUE,4X, 8HSIGMPRO 116
      2AOCT,6X, 6HTANMOD,6X, 5HRATIO,/)              PRO 117
105     FORMAT (11E12.4)                              PRO 118
C

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END	PRD	121
SUBROUTINE SPLINE (NPN,XP,YP,YDP)	SPL	2
DIMENSION XP(20), YP(20), YDP(20), H(20), AI(20), BI(20), CI(20),	SPL	3
DI(20)	SPL	4
NP1=NPN-1	SPL	5
DO 5 M=1,NP1	SPL	6
5 H(M)=XP(M+1)-XP(M)	SPL	7
SLOP1=FD(H(1),H(2),YP(1),YP(2),YP(3))	SPL	8
SLOPN=BD(H(NPN-2),H(NPN-1),YP(NPN-2),YP(NPN-1),YP(NPN))	SPL	9
CALL CDFRIT (NPN,XP,YP,SLOP1,SLOPN,AI,BI,CI,DI)	SPL	10
CALL TRIDGNL (NPN,AI,BI,CI,DI,YDP)	SPL	11
RETURN	SPL	12
C	SPL	13
END	SPL	14
SUBROUTINE CDFRIT (NPN,XP,YP,SLOP1,SLOPN,AI,BI,CI,DI)	COF	2
DIMENSION XP(20), YP(20), AI(20), BI(20), CI(20), DI(20)	COF	3
AI(1)=0.0	COF	4
BI(1)=(XP(2)-XP(1))/3.	COF	5
CI(1)=BI(1)/2.	COF	6
DI(1)=(YP(2)-YP(1))/(XP(2)-XP(1))-SLOP1	COF	7
AI(NPN)=(XP(NPN)-XP(NPN-1))/6.	COF	8
BI(NPN)=AI(NPN)*2.	COF	9
CI(NPN)=0.0	COF	10
DI(NPN)=(YP(NPN)-YP(NPN-1))/(XP(NPN)-XP(NPN-1))+SLOPN	COF	11
N1=NPN-1	COF	12
DO 5 I=2,N1	COF	13
AI(I)=(XP(I)-XP(I-1))/6.	COF	14
BI(I)=(XP(I+1)-XP(I-1))/3.	COF	15
CI(I)=(XP(I+1)-XP(I))/6.	COF	16
DI(I)=(YP(I+1)-YP(I))/(XP(I+1)-XP(I))-(YP(I)-YP(I-1))/(XP(I)-XP(I-1))	COF	17
1 (I-1))	COF	18
5 CONTINUE	COF	19
RETURN	COF	20
C	COF	21
END	COF	22
SUBROUTINE TRIDGNL (NPN,AI,BI,CI,DI,YDP)	TRI	2
DIMENSION AI(20), BI(20), CI(20), DI(20), YDP(20), Q(30), U(30)	TRI	3
P=BI(1)	TRI	4
Q(1)=-CI(1)/P	TRI	5
U(1)=DI(1)/P	TRI	6
DO 5 K=2,NPN	TRI	7
P=AI(K)*Q(K-1)+BI(K)	TRI	8
Q(K)=-CI(K)/P	TRI	9
U(K)=(DI(K)-AI(K)*U(K-1))/P	TRI	10
5 CONTINUE	TRI	11
YDP(NPN)=U(NPN)	TRI	12
N1=NPN-1	TRI	13
DO 10 L=1,N1	TRI	14
K=N1+1-L	TRI	15
YDP(K)=Q(K)*YDP(K+1)+U(K)	TRI	16
10 CONTINUE	TRI	17
RETURN	TRI	18
C	TRI	19
END	TRI	20
FUNCTION ET(R1,R2,Z1,Z2,Z3,S1,S2)	ET	2
HJ=Z2-Z1	ET	3
T1=-0.5*(S1*(Z2-Z3)**2)/HJ	ET	4
T2=0.5*(S2*(Z3-Z1)**2)/HJ	ET	5
T3=(R2-R1)/HJ	ET	6
T4=-(S2-S1)*HJ/6.	ET	7

	ET=T1+T2+T3+T4	ET	8
	RETURN	ET	9
C		ET	10
	END	ET	11
	FUNCTION FD(S1,S2,R1,R2,R3)	FD	2
	IF (S1-S2) 5,10,5	FD	3
5	FD=(R2-R1)/S1	FD	4
	RETURN	FD	5
10	FD=(-3.*R1+4.*R2-R3)/(2.*S1)	FD	6
	RETURN	FD	7
C		FD	8
	END	FD	9
	FUNCTION BD(S1,S2,R1,R2,R3)	BD	2
	IF (S1-S2) 5,10,5	BD	3
5	BD=(R3-R2)/S2	BD	4
	RETURN	BD	5
10	BD=(3.*R3-4.*R2+R1)/(2.*S1)	BD	6
	RETURN	BD	7
C		BD	8
	END	BD	9
	FUNCTION ORDINET(A,B,C,D,E,F,P)	ORD	2
	HJ=D-C	ORD	3
	B1=D-P	ORD	4
	B2=P-C	ORD	5
	A1=B1**3	ORD	6
	A2=B2**3	ORD	7
	T1=A1*A/(6.*HJ)	ORD	8
	T2=A2*B/(6.*HJ)	ORD	9
	T3=(E-A*HJ**2/6.)*(D-P)/HJ	ORD	10
	T4=(F-B*HJ**2/6.)*(P-C)/HJ	ORD	11
	ORDINET=T1+T2+T3+T4	ORD	12
	RETURN	ORD	13
C		ORD	14
	END	ORD	15

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